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OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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COMING MEETINGS OF THE SOCIETY

November 11, *New York City*, Engineering Societies Building. Paper: A New Centrifugal Pump with Helicoidal Impeller, C. V. Kerr.

November 19, *Boston, Mass.*, joint meeting under auspices of Boston Section of Civil Engineers. Paper: Engineering Lessons from the Ohio Floods, John W. Alvord.

November 19, *Chicago, Ill.* Subject: The Iron and Steel Industry of the Chicago District. Paper by Wm. A. Field, and discussion by other prominent men.

November 19, *Philadelphia, Pa.*, joint meeting with Franklin Institute. Paper: Producer Gas from Low-Grade Fuels, R. H. Fernald.

November 20, *Cincinnati, Ohio.* Paper: Stellite, by Elwood Haynes.

November 21, *New Haven, Conn.*, Mason Laboratory, Sheffield Scientific School. Afternoon and evening sessions. See page 7 for program.

December 2–5, *Annual Meeting*, Engineering Societies Building, New York. See page 4 for program.

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ANNUAL MEETING

Plans are now practically complete for the coming Annual Meeting and the program is published herewith in its final form in so far as the arrangement of the sessions and of the social events is concerned, there remaining only the titles of a few papers not in hand at the time of its preparation, to be announced later.

It is seldom that a meeting of the Society has been arranged with so wide a diversity of subjects to be discussed. There will be two general sessions, one on Power Plant subjects, and one comprising various papers which have been prepared on investigations and tests of apparatus of different types. There will then be several sessions devoted to special interests. One of these is a Railroad Session on Steel Freight Cars, with two strong papers; another on subjects relating to Textile Manufacture, covering the general field of Mill Engineering; another on Fire Protection supplementing the one held at Baltimore last Spring, the papers relating to certain important engineering questions that enter into fire protection, while those read at Baltimore dealt with conflagrations and other larger aspects of the subject. There will also be a meeting with Gas Power papers.

The feature of the evening events will be the presentation of the Grashof Medal, which was conferred upon George Westinghouse by the Verein deutscher Ingenieure at Leipzig. This will be followed by a lecture on Leonardo da Vinci by John W. Lieb, Jr., based upon his remarkable collection of manuscripts, drawings and books relating to the life and work of this distinguished engineer and artist.

On Thursday evening there will be a German Dinner, which it is expected will be largely attended, at which those who were unable to participate in the trip will have the pleasure of hearing accounts of many of the remarkable events retold. The dinner will be followed by a dance and there will be an opportunity for those not desiring to participate in the dinner to take part in the dancing.

It is probable that in addition to the usual excursions provided around New York, there will also be one or two to points of interest outside the city. Thursday and Friday afternoons are left entirely free for excursions.

PROGRAM

Tuesday Evening, December 2

PRESIDENTIAL ADDRESS, followed by RECEPTION.

Wednesday Morning, December 3

BUSINESS MEETING, followed by Professional Session, with the following papers:

NOTES ON THE FURTHER OPERATION OF LARGE BOILERS OF THE DETROIT EDISON COMPANY, J. W. Parker

ON SETTING TASKS FOR FIREMEN AND MAINTAINING HIGH EFFICIENCY IN BOILER PLANTS, Walter N. Polakov

PROPERTIES OF STEAM, R. C. H. Heck

Wednesday Afternoon

RAILROAD SESSION

(Papers contributed by Sub-Committee on Railroads)

STEEL UNDERFRAME BOX CARS, G. W. Rink

STEEL FRAME BOX CARS, R. W. Burnett

Wednesday Evening

PRESENTATION OF THE GRASHOF MEDAL by the Verein deutscher Ingenieure to George Westinghouse, Past-President and Honorary Member, The American Society of Mechanical Engineers.

ADDRESS, illustrated by lantern views, on LEONARDO DA VINCI—ENGINEER AND ARTIST, by John W. Lieb, Jr., Past-President American Institute of Electrical Engineers, and Past Vice-President, The American Society of Mechanical Engineers

Thursday Morning, December 4

PROFESSIONAL SESSION

EFFICIENCY OF ROPE DRIVING AS A MEANS OF POWER TRANSMISSION, E. H. Ahara

Comparative Tests of Lineshaft Bearings, Carl C. Thomas, E. R. Maurer and L. E. Kelso

Pitot Tubes for Gas Measurement, W. C. Rowse

Tests of Vacuum Cleaning Systems, J. R. McColl

Tests upon the Transmission of Heat in Vacuum Evaporators, E. W. Kerr.

The Art of Enameling, or the Coating of Steel and Iron with Glass, Raymond F. Nailler

SIMULTANEOUS SESSIONS

CEMENT SESSION

There will be an opportunity for those interested in Cement Manufacture, to gather for an informal discussion of various topics.

MACHINE SHOP PRACTICE

(Papers contributed by Sub-Committee on Machine Shop Practice)

Continuous Manufacturing by Placing Machines in Accordance with Sequence of Operations, Oscar F. Bornholt

Gears for Machine-Tool Drives, John Parker

Cast-Iron for Machine-Tool Parts, Henry M. Wood

A Record of Pressed Fits, C. F. MacGill

TEXTILES

It is expected that papers will be contributed by the Sub-Committee on Textiles, on Cotton Conveying Systems, Specifications for Factory Timbers, Costkeeping in Textile Mills, and The Use of Sprinkler Systems for Heating in Textile Mills.

GAS POWER

(Paper contributed by the Gas Power Section)

A New Process for Cleaning Producer Gas, H. F. Smith

Other papers are expected on the subject of the Diesel Engine

Thursday Afternoon

Excursions to points of interest in New York and vicinity.

Thursday Evening

German Dinner, reproducing one of the menus from the trip abroad. This will not only be a reunion of those who went on the trip, but is being arranged with a view to giving those who were unable to participate some idea of the many interesting events which the American guests enjoyed. Addresses on the German trip will be made, illustrated by slides.

A Dance will follow the dinner.

Friday Morning, December 5

Announcement of Tellers of Election and presentation of the President-Elect. This will be followed by a session on

FIRE PROTECTION

(Papers contributed by the Sub-Committee on Fire Protection)

THE FIRE HAZARD IN TURBO-GENERATORS, G. S. Lawler

EXTINGUISHING FIRES IN OILS AND VOLATILE LIQUIDS, Edw. A. Barrier

CONTROL OF AUTOMATIC SPRINKLER VALVES, Fred J. Miller

Other papers are expected on INSTALLATIONS FOR HANDLING FUEL OIL, GASOLENE, ETC.; FEATURES OF CONSTRUCTION OF FIRE PUMPS; and THE DESIGN AND CONSTRUCTION OF ELEVATED TANKS

Friday Evening

COLLEGE REUNIONS

It has been the custom for the alumni of certain of the technical schools to hold reunions in New York at about this time of the year, and an opportunity will be offered for such gatherings on this evening.

The alumni of Stevens Institute of Technology are arranging for a theater party, in which the Society and their friends are invited to take part. Supper and informal dancing at the Hotel Astor will follow. Information regarding tickets, etc., may be obtained from Mr. R. K. MacMaster, at the Society's rooms.

Worcester Polytechnic Institute will hold its annual dinner at the Hotel Astor, and it is hoped that as many members of the Society as possible will participate. Notice of such intention and any inquiries regarding details should be sent to Mr. F. O. Price, Pratt Institute, Brooklyn.

The Polytechnic Institute of Brooklyn will give a reunion dance in the rooms of the Society. Those desiring to attend are requested to communicate with Prof. W. D. Ennis at the Institute.

A dinner of the Alumni of Yale University will be held at the Yale Club of New York. All graduates of Yale are invited to attend, and to communicate with Mr. Bradley Stoughton, 25 W. 39th St., Secy., A. I. M. E., New York.

RAILROAD TRANSPORTATION AND HOTELS

There will be no special railroad rates for the Annual Meeting this year. Those who expect to attend are urged to make early arrangements for hotel accommodations which must, as usual, be made individually.

EXHIBITION OF SAFETY APPLIANCES

The attention of the members who will attend the Annual Meeting is called to the International Exposition of Safety and Sanitation which will be held under the auspices of the American Museum of Safety in the New Grand Central Palace, New York, from December 11 to 20. It is expected that the exposition will represent the progress in America of safety and sanitation, covering accident prevention, industrial, city, home and social hygiene, and mutuality enterprises. This will be the first comprehensive exposition of this nature

ever held in America and by special act of Congress the foreign exhibits will be admitted free of duty.

NEW HAVEN MEETING

The date of the meeting in New Haven has been changed from November 19, to Friday, November 21, and will as previously announced be held in the Mason Laboratory of the Sheffield Scientific School, Yale University. The program is as follows:

Afternoon Session, 3.00 *to* 5.00 *p.m.*

E. S. Cooley, *Chairman*

Topic: Coöperative Industrial Research

Coöperative Industrial Research at the Sheffield Scientific School with Connecticut Manufacturers, by L. P. Breckenridge, professor of mechanical engineering, Yale University.

A Central Bureau for Industrial Research, by Linn Bradley, of the Research Corporation of New York.

Research Work of the Bureau of Mines, by O. P. Hood, chief mechanical engineer of the United States Bureau of Mines.

Coöperation of State and University for Industrial Research, by a representative of the engineering experiment station of the University of Illinois.

History of the Manufacture of Brass, by W. B. Edwards, Ansonia, Conn.

Intermission and Dinner, 5.00 *to* 7.30 *p.m.*

The new laboratory of electrical engineering and the Mason laboratory will be open for inspection.

Dinner will be served at the Yale dining hall at 6.00 p.m. and all visitors will be welcome at this social part of the meeting. Price, fifty cents.

Evening Session, 7.30 *to* 9.30 *p.m.*

Safety Devices used in Connection with Grinding Wheels, by R. G. Williams of the Norton Company, Worcester, Mass.

Experiments with Residence Heating Boilers at the Mason Laboratory, by D. B. Prentice of New Haven.

Motor Car Testing, by E. H. Lockwood, assistant professor of mechanical engineering, Yale University, with demonstration of automobile testing apparatus in the laboratory.

COMING MEETINGS IN LOCAL CENTERS

The Chicago Section is now entering upon its second year, with plans for increased activity. During the past year five meetings have been held, with an average attendance of over sixty, and it is believed that this number will be considerably exceeded the coming year.

The Chicago membership take a great deal of satisfaction in the

fact that Dr. Goss, the President of the Society, is now located in Chicago, having obtained a year's leave of absence from the University of Illinois in order to act as chief engineer for the Chicago Association of Commerce committee on smoke abatement and the electrification of railway terminals.

It is proposed to hold four meetings during the coming season, the first of which is scheduled for Wednesday, November 19. In connection with each of these meetings there will be a dinner, the entire meeting taking place in the dining room, thus making possible informal discussion. The subjects to be discussed are as follows: First meeting, the iron and steel industry of the Chicago district; second meeting, steam power plants; third meeting, internal-combustion engines; fourth meeting, refrigeration. At the November meeting, Wm. A. Field, general superintendent of the Illinois Steel Company's plant at South Chicago, who has been one of the prominent figures in the development of this industry, will be the principal speaker, and there will be discussion by other prominent men. The Secretary of the Chicago Section is Mr. Paul P. Bird, 120 West Adams Street, Chicago, from whom further information can be obtained.

PHILADELPHIA MEETINGS

In Philadelphia there will be a joint meeting with the Franklin Institute on November 19, with a paper on the subject of Producer Gas from Low-Grade Fuels, by Prof. R. H. Fernald. On December 9 it is planned to hold a symposium on how far shall judgment be exercised in the interpretation of engineering specifications, with several short papers from prominent men. In January and February joint meetings will be held, the first with the Engineers Club, with a paper on Some Recent Improvements in Steam Locomotives, by George R. Henderson, and the second with the American Institute of Electrical Engineers, on Business Training for the Engineer, with discussion by Dr. Alex. C. Humphreys, Theodore I. Jones and Ralph D. Mershon. The March meeting will probably be devoted to the subject of Recent Developments in Turbine-Driven Centrifugal Blowers, the author of the paper being as yet unannounced.

BOSTON MEETINGS

Boston members also have their plans for the coming season well under way. On November 19 there will be a joint meeting of the representatives of the various engineering societies having members in Boston, under the auspices of the Boston Society of Civil Engineers,

at which a paper on Engineering Lessons from the Ohio Floods will be presented by John W. Alvord of Chicago. The December meeting will be under the auspices of the Boston Section of the American Institute of Electrical Engineers, while our Society will be responsible for the January meeting, and in February the annual dinner will be held.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. The Membership Committee and in turn the Council urge the members to assume their share of responsibility in receiving into membership these candidates by advising the Secretary promptly of any candidate whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before December 10, 1913:

Abbott, Henry W., Asst. to Master Mech., The Penna. Steel Co., Steelton, Pa.
Ackerman, Geo. E., Member of Firm, Jacobson & Ackerman, Grand Rapids, Mich.
Allen, Percy J., Member of Firm, American & Brasilian Engrg. Co., Curityba, Brazil.
Armes, Wm. A., Supt. & Res. Engr., F. W. Bird & Son, Pont Rouge, P. Q., Canada.
Armstrong, Geo. S., Engr., Suffern & Son, London, Eng.
Ayars, Wm. Stewart, Prof. of M.E. & E.E., Nova Scotia Tech. Coll., Halifax, N. S.
Belcher, Thos. H., Engr. & Rep., The Black-Clawson Co., Hamilton, Ohio.
Berge, Geo. H., Sales Mgr., Illinois Stoker Co., Chicago, Ill.
Bidwell, Carlyle D., Mech. Engr., International Harvester Corp., Akron, Ohio.
Blumenfeld, Ralph, 241 West 108th St., New York.
Bristol, Howard H., The Bristol Co., Waterbury, Conn.
Brown, Eugene L., Jr., Ch. Deputy Insp. of Boilers, Elev. & Smoke Abatement, St. Louis, Mo.
Carroll, John T., Asst. Genl. Supt., M.P., B. & O. RR., Baltimore, Md.
Cassidy, Perry R., Instr. in Steam Engrg., State Univ. of Ky., Lexington, Ky.
Clouser, Geo. L., Special Apprentice, P. & R. R.R., Reading, Pa.
Douglas, Morris D., Mech. Engr., Exp. Dept., Penna. Steel Co., Steelton, Pa.
Eastwood, Sidney K., Draftsman, Day & Zimmerman, Philadelphia, Pa.
Ellingham, Robt. W., Works Mgr., Hendee Mfg. Co., Springfield, Mass.
Evans, Wm. A., New England Mgr., Griscom-Russell Co., Boston, Mass.
Foote, Geo. W., Salesman with Jacob Mazer, Acoustical Engr., Pittsburgh, Pa.
Frölich, Fr., Secy. of Asso'n of German Machine Shops, Düsseldorf, Germany.
Fuller, John, Genl. Mgr., Conveying Machinery Co., New York.
Gerber, Samuel R., Task-setter, Remington Typewriter Co., Ilion, N. Y.
Giller, Frederick S., Asst. Plant Engr., Western Elec. Co., London, Eng.
Glynn, Frank L., Director, Trade Education in Public Schools, New Haven, Conn.
Hagadorn, Thos. H. X., Draftsman, Arkansas Valley Smelter, Leadville, Colo.
(Committee solicits references.)
Hamilton, Chester B., Jr., Mgr., Hamilton Gear & Mch. Co., Toronto, Canada.
Hanscom, Wm. W., Cons. Engr., San Francisco, Cal.
Helmreich, L. W., Head of Dept. of Elec., Ranken Mech. School, St. Louis, Mo.
Hemstrought, Harry B., Mech. Draftsman, Crowell-Sherman-Stalter Co., Genl. Contrs., Lyons N. Y.
Howells, Frank E., Supt. of Shops, The Penna. Steel Co., Steelton, Pa.

KAIGHN, HERBERT E., Ballistic Engr., E. I. DuPont Powder Co., Experimental Sta., Henry Clay P. O., Del.
LEKBERG, CARL H., Asst. Prof. of M.E., Univ. of Maine, Orono, Me.
LINLEY, FRED. H., Cor. Engr., Steam Turbine Dept., Allis-Chalmers Mfg. Co., W. Allis, Wis.
LITTLE, JAMES E., Mech. Engr., The Spanish-American Iron Co., Steelton, Pa.
LYNCH, FRANCIS J., Mech. Supt., Peerless Tube Co., New York.
McKAIG, W. WALLACE, Genl. Mgr., The McKaig Mch., Fdy. & Supply Wks., Cumberland, Md. (Committee solicits references.)
MAURHOFF, PRESLEY A. L., Rep. & Engr., Standard Plunger Elevator Co., New York.
MURPHY, GEO. F., Sales Rep., Busch-Sulzer Bros.-Diesel Eng. Co., St. Louis, Mo.
OBERG, ERIK V., Associate Editor, Machinery, New York.
ORTNER, LOUIS, Fuel Expert, Dept. Water, Gas & Elec., The City of New York.
PERRY, EDWARD D., Mech. Engr., A. L. Ide & Sons, Springfield, Ill.
PHILLIPS, JACKSON C., Engrg. Dept., Revere Rubber Co., Providence, R. I.
REDDIG, WM. H., Genl. Supt., Motor Mfg., Continental Motor Mfg. Co., Detroit, Mich.
RICKCORD, REGINALD V. G., Mech. D'ftsman, Cluett, Peabody & Co., Inc., Troy, N. Y.
ROLLINS, HENRY M., Supt., Gulfport Creosoting Co., Gulfport, Miss.
SCHAEFFER, SIMON S., Ch. Mech. Engr., Thompson-Starrett Co., New York.
SCOTT, JAMES, Cons. Sugar Engr., Pacific Commercial Co., Manila, P. I.
SEILER, PAUL, Ch. Engr., Pacific Rolling Mill Co., San Francisco, Cal.
SLOAN, BEN, Salesman, Pratt & Whitney Co., New York.
SMALL, FRANK W., Steam Dept., Pacific Gas & Elec. Co., San Francisco, Cal.
SULLIVAN, JOHN L., Asst. Foreman, Westinghouse E. & M. Co., E. Pittsburgh, Pa.
WADDELL, JOS. A., JR., Genl. Supt., Spencer Heater Co., Scranton, Pa.
WEBB, WILFRED LEP., Director & Ch. Engr., Crossley Bros., Ltd., Otto Gas Engine Works, Manchester, England.
WEBER, HERMAN R., Ch. Engr. & Genl. Mgr., The Palmer Forced Draft Slack Burner Co., Fort Scott, Kan.
WENDLE, GEO. E., Asst. Genl. Mgr., Lycoming Edison & W'msport Pass. Ry. Cos., Williamsport, Pa.
WILLIAMS, IRVING, Salesman, Brown & Sharpe Mfg. Co., Providence, R. I.
WOODWORTH, JOSEPH V., Cons. Engr. & Mfgrs. Rep., Worcester Pressed Steel Co., Worcester, Mass.
ZIPF, JOHN, 1525 Fulton St., San Francisco, Cal.

PROMOTION FROM ASSOCIATE

ANDERSON, LESLIE D., Supt., U. S. Smelting Co., Midvale, Utah.

PROMOTION FROM JUNIOR

BRADSHAW, GRANT D., Steam Engr., Cambria Steel Co., Johnstown, Pa.
CONNOLLY, JAS. H., Mech. Engr., The Taft-Peirce Mfg. Co., Woonsocket, R. I.
COOK, WM. P., JR., Asst. to Ch. Mech. Engr., Thompson-Starrett Co., New York.
DURANT, ALDRICH, Engr. in charge & Agent, MacArthur, Perks & Co., Ltd., and MacArthur Bros., Havana, Cuba.
SNODGRASS, JOHN M., Asst. Prof. of Ry. Engrg., Univ. of Ill., Urbana, Ill.
TALLMADGE, WEBSTER, Master Mechanic, Norwood Mill, Bird & Son, E. Walpole, Mass.
TORRANCE, CHAS. E., JR., Mech. Engr., Norwood Engrg. Co., Northampton, Mass.

SUMMARY

New applications	59
Promotion from Associate	1
Promotion from Junior	7
Total	67

REPORT OF THE GERMAN MEETING COMMITTEE

At the meeting of the Council on October 14, the following report was presented by the committee having in charge the arrangements for the trip to Germany:

To the President and Council:

As Chairman of the Committee of Arrangements for the Joint Meeting with the Verein deutscher Ingenieure Leipzig 1913, I beg to report as follows:

This Committee began its activities with the general circular of August 27, 1912, followed by twelve other circulars and eleven postal cards giving full particulars of the program and itinerary. After careful search among available steamers, the great steam yacht Victoria Luise, 17,000 tons, of the Hamburg-American Line, was selected, and the travel bureau of this same line chosen to make all arrangements for the land trip of twenty days. As the steamer could carry about 600 passengers our right of choice of rooms was limited to March 1, 1913, but later extended a short period. By February 19, 209 had registered in the official party for the land tour in Germany, and we were informed that our final limit was fixed at 200 engineers and 100 ladies, as neither the special trains nor the hotels in Germany could take more than 300 in all. From the official lists there were 303 scheduled to sail on the steamer and 42 to join the party at Hamburg, a total of 345; but on leaving Hamburg June 22, an actual count showed 303 on the train. There were 226 passengers not of our party on the sailing list. Owing to my long and repeated absences from New York most of the preliminary work was done by the other members of the Committee under the able and untiring leadership of Mr. J. W. Lieb, Jr., the Vice-Chairman.

We sailed from Hoboken at 10:10 a.m. on Wednesday, June 10, 1913. Secretary Rice and I were the only members of the original committee on board. Under authority given me by the Council I increased the committee to 17, making with the Secretary and his assistant 19 in all, as follows:

EXECUTIVE COMMITTEE

E. D. Meier, *Chairman*
J. R. Freeman, *Vice-Chairman*
W. R. Warner, *Vice-Chairman*
James Hartness
Jesse M. Smith

COMMITTEE ON EXCURSIONS

J. G. Brill, *Chairman*
A. M. Greene, *Vice-Chairman*
L. P. Breckenridge
H. M. Leland
E. E. Keller

COMMITTEE ON SPEAKERS

H. L. Gantt, *Chairman*
H. G. Reist, *Vice-Chairman*
Jesse M. Smith
L. W. Nelson
E. E. Keller

COMMITTEE ON RESOLUTIONS

Sen. Newell Sanders, *Chairman*
F. R. Low, *Vice-Chairman*
H. M. Leland
F. G. Kretschmer
Wm. A. Doble

The Committees on Entertainment, Acquaintanceship and Fourth of July celebration had been appointed some time before and were already at work. The Entertainment Committee led by Prof. and Mrs. A. M. Greene, Jr., had provided 19 principal events, leaving no time for such diversions as sacrifices to Neptune even if the weather had suggested them.

But the steamer was steady and the sea smooth so that the entire program was enjoyable. The 226 other passengers were invited to join in our exercises, by individual invitations sent to their cabins. They entered into the spirit of the occasion with alacrity and at the close of the trip thanked us in a poem posted on the bulletin board, signed by all individually. On June 15 the captain gave a special dinner in honor of the twenty-fifth anniversary of the accession to the throne of Emperor William the Second at which our congratulatory address was read. This was responded to by a German orator with much feeling. The resolutions were sent to Berlin by aerogram the next morning.

On our arrival at Plymouth at 5 o'clock in the morning of June 18, Professor Matschoss, representing the Verein deutscher Ingenieure, and Engineer Kroebel, president, and Director Molsen and Professor Frasch, members, of the Hamburg branch of the V. D. I., came aboard to welcome us to Europe, and three officials of the Hamburg-American Travel Bureau opened an office on board to issue all the necessary circulars and tickets to the entire party. After breakfast President Kroebel delivered his address of welcome in such fervent and ardent German that its spirit was fully understood by all in our party and a cordial friendship created which thenceforth grew with every new committee we met, and they were many. These were: (1) The

council of the V. D. I., of members; (2) the honorary reception committee, 52 members; (3) eight local reception and entertainment committees, 329 members.

While naturally many of these were members of several committees, they included not less than 300 men prominent in government, manufacturing, railways and various branches of engineering, and as such they bore to our visiting party the welcome of the Verein of more than 24,000 engineers, of the vast and varied industries of Germany, of ten municipalities, of six sovereign states, and of the great German Empire.

It appears that when the V. D. I. had received our acceptance of its invitation a large number of its forty-eight branch societies applied for the privilege of receiving and entertaining us. With just regard to the time and strength of our party, the Council finally selected eight local branches; no sooner was this done than the ten cities covered by these branches demanded their right to participate in the welcome. Forty-six excursions to prominent engineering works and industrial concerns were arranged, explanatory lectures prepared, the transportation and commissariat arranged, and all with that German thoroughness and forethought that made it possible to enjoy everything with the greatest benefit and least fatigue.

The principal events were of course the two official joint meetings with the V. D. I. at Leipzig. The first, on June 23, after the official welcome, was devoted to two papers: one by Privy Councillor Lamprecht, on The Technic and Culture of the Present Day; the second, by Dr. W. F. M. Goss, President Am. Soc. M. E., on Foundations of American Engineering. Both treated their subjects in a broad and thorough manner, and it was instructive and gratifying to hear how the conclusions reached testified to the solidarity of engineering thought in the two great nations.

The King of Saxony with a brilliant court was an attentive listener for a full hour and was duly promoted to Doctor of Engineering. Our honored past-president, George Westinghouse, was unanimously voted the gold Grashof medal for his contributions to engineering science. President von Miller presented an artistic plaque to our Society commemorative of the occasion.

The second meeting, on June 24, was devoted to industrial efficiency. The subject was introduced by a comprehensive

paper by James M. Dodge, Past-President, followed by an equally thoughtful one by Professor Schlesinger of the Technical University of Charlottenburg. An interesting and warm discussion followed in which the original, scientific and humanitarian work of our Past-President Taylor was duly acknowledged as fundamental and leading. The itinerary of our trip has been fully published. Having our special train always at our disposal and the professional promptness of our party harmonizing with the perfect arrangements of the travel bureau, we were able to carry out the program as published in advance, although it included in addition to the study of the plants freely opened for our inspection, our grateful acceptance of many social functions artistically arranged and gracefully tendered, numbering no less than fifteen formal banquets and receptions, fourteen luncheons and collations, twelve concerts, lectures and special performances, and ten excursions by rail and boat. In all of these there were present some 200 or more of our German hosts. In several we had occasion to admire the democratic attitude of German officialdom at social functions. Thus, the welcome to Berlin in a carefully prepared speech by a high official of the imperial ministry of the interior, the polite comradeship of Prince William of Saxe-Weimar at Heidelberg, the visit of the aged Prince Regent Ludwig of Bavaria to our excursion steamer on Lake Starnberg in the pouring rain, with an hour's friendly chat on canals, and the uniform urbanity of the lord mayors of the cities visited.

The social functions had their own distinctive features in each city. There was manifest an amicable rivalry in giving us the best they could devise, especially as suggested by some local or historical fact, and worked out with the aid of good home talent in the arts employed. To mention any of these without a full description in this short report would savor of want of appreciation of the beauty and meaning of the performances. Full details are available in the letters, printed records, and photographs in the hands of the Secretary and will be embodied in the book being prepared at the demand of the official party.

It is my pleasant duty to record the conscientious and telling labors of our various committees which so thoroughly coördinated the events that there was not the slightest hitch anywhere. The value of this was brought home to me by the Consul General of the United States in Berlin, when I called on him some

weeks later. He said that during the past twelve months, two large American parties visiting Germany had inadvertently given serious offense by some omission, but that he had received from various cities and officials such gratifying reports of our party that these incidents were now forgotten and the American engineers accepted as the true representatives of our people.

Praise is due also to a group of graduates and undergraduates of several of our technical colleges for their untiring work as messengers on our trains and in hotels in distributing papers and packages, calling meetings and giving information.

We were all deeply impressed by these facts concerning our German hosts: That they believe laws are made to be obeyed, and though they are not blessed with such myriads of laws as we, those they have they respect; that the discipline learned in school and away has built up an industrial prowess capable of even greater conquests than those of the present; that the builders of the great empire desire peace to enable them to continue the beneficent battle compelling all natural force to the service of man; that nowhere has the engineer won a higher social standing than is accorded him in Germany; and that his ethical sense and ideals are the same in all countries and on fully as high a level as those of the older professions.

Respectfully submitted,

E. D. Meier, *Chairman.*

TASK SETTING FOR FIREMEN AND MAINTAINING HIGH EFFICIENCY IN BOILER PLANTS

By Walter N. Polakov

ABSTRACT OF PAPER

The determination of the practical maximum economy of boiler room operation is the subject of this discussion. The question is twofold in its nature: (*a*) how to obtain this maximum economy of operation, and (*b*) how to secure the permanency of the results attained. The first part of the question involves the theoretical research into the problem which embraces: (*a*) analysis of variables, (*b*) limiting influence of variables on maximum, and (*c*) dependence of results from time rate. This part deals with methods of experimental determination of maximum theoretical efficiency obtainable under given conditions, and incidentally refers to the graphical method of study of boiler trials as applied to actual examples of the writer's tests.

The well-known falling short of test results in everyday performances forms the connecting link with the second part of the paper, and it is shown how the results of theoretical research can be made practically obtainable in regular service. This embraces the methods employed by the writer in studying the psycho-physiological element of the problem. In order that the prescribed conditions be maintained and the desired results of high economy of operation be accomplished, not spasmodically, but day in and day out, the task put before men ought to be (*a*) possible, and (*b*) desirable.

The possibility of accomplishment of task is governed by (*a*) proper coördination of conditions and supplies with power demand and existing facilities; (*b*) proper guidance of men in their work; (*c*) proper balance of strain during the work and regain of physical losses of the individual during intervals between working periods. Part *c* complements the common method of time studies, with a new method of physical studies of the effect of work on the health of workingmen and a method of scientific determination of length of working day.

The desirability of accomplishment of a task set within men's possibilities requires the study of: (*a*) physical stimuli, (*b*) psychical stimuli, and (*c*) social stimuli. To the group (*a*) is referred payment of bonus, better surroundings, shorter hours, sanitary conditions, etc. To the group (*b*) factors like sporting spirit, confidence in records, relationship with management, desire to study and advance, etc., are referred. To the last group (*c*) belong such stimuli (favorable or not) as attitude of fellow workmen, of trade unions and socialist party, of members of the family, and condition of labor market, legal regulations, etc. To the above plan are added examples of records from practice, and description of methods greatly simplifying the working out of records and logs.

TASK SETTING FOR FIREMEN AND MAINTAINING HIGH EFFICIENCY IN BOILER PLANTS

By Walter N. Polakov, Philadelphia, Pa.

Member of the Society

The object of this paper is to outline a method for the accurate determination and permanent attainment of maximum economy in daily boiler room practice in the power plant by the task-setting method. The problem is two-fold: First, the determination of the conditions which will result in a maximum operating economy; and second, the determination of the factors which will secure the permanent attainment of these best conditions. The writer recently had an opportunity to reorganize the power plant of a large public utility company, and the methods employed to determine the tasks for the firemen and to attain the improvement in results which they represent in everyday running, met with such success that a report on the subject seems to be warranted.

2 The engineering function of a boiler plant is deliberately to convert the thermochemical energy latent in fuel into the volume energy latent in steam, through a process of trans-power, while the commercial function is to generate steam of required quality and in a required quantity at the lowest cost compatible with the circumstances. The problem before the management, however, is to determine and provide the necessary and sufficient conditions, the fulfillment of which will bring about and assure the permanency of the desired predetermined results.

3 The degree of engineering perfection in a boiler plant is generally reckoned in terms of thermodynamic efficiency, but this criterion alone is both inaccurate and insufficient. It is inaccurate inasmuch as the inherent thermodynamic efficiency of the plant, if determined either by calculation or by experiment under ideal con-

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ditions, is not attained in practice; if determined from everyday performance it is short by some unknown quantity, depending upon the variable "human element." It is insufficient since the conception of thermodynamic efficiency of a boiler plant does not include the "time element" which is the chief determining factor in our industrial, commercial and social lives. Thus, the thermodynamic efficiency can represent correctly the degree of perfection of the whole plant only if supplemented by correction factors taking into account the human and time elements, and is only one of many factors to be considered in the problem of reckoning the industrial efficiency of a plant.

4 As in differential calculus, the place of maxima depends upon the limiting conditions of variables and constants, so in our problem the proper and complete solution can be found only by strict observance of the rules of scientific investigation, and the steps to be taken in this research work can be grouped chiefly as follows: (*a*) analysis of elements, (*b*) study of limiting effects of variable and constant elements on the maximum efficiency of partial processes, and (*c*) determination of maximum effect and the corelation of determining factors. When in this manner we learn what can be accomplished and what are the conditions *necessary* for it, we have further to investigate whether these conditions are *sufficient*. Our knowledge would be insufficient if we did not consider the element of human will to attain the task set, and the stimulating factor to keep permanently at work the power of will to maintain these known favorable conditions.

5 The well-known fact that the high thermal efficiency attained by experts during the boiler tests is seldom maintained in everyday practice is due to gross neglect on the part of the management to:

a record the conditions causing the high efficiency during the test

b instruct the men how to regulate these conditions in order to duplicate the test results, and

c provide an incentive to the men for striving for the purpose desired by the management or owners

To this we may add that in most instances there is no assurance or proof that the high test efficiency was really the highest attainable.

6 The work of testing steam boilers as it is usually conducted is not infrequently done by young college graduates or sometimes by the boiler room force, even in the plants of conservative and reputable companies. The data thus obtained is seldom reliable and com-

plete, and even if every factor, however insignificant, is measured and recorded the results are almost equally worthless, except that occasionally such tests disclose a serious leak somewhere and enable steps to be taken to remedy the isolated cause of loss. As a rule these evaporative tests are of no further use than to satisfy the owner's curiosity or fancy to see mere figures of efficiency and load and sometimes heat balance. As a consequence the work of testing boilers is brought in this country to disrepute, to the auxiliary role of a "selling trick."

7 A mere heat balance is unable to furnish answers to the many questions of utmost importance for determining of conditions for the most economic steam generation. Lack of positive, well grounded principles as well is responsible repeatedly for faulty construction of furnaces and arrangement of baffles and gas passages. The average data of most tests are of very little value inasmuch as such factors as attention and skill of firemen are dumped into the same heap with the factors of boiler and furnace construction, and of properties of fuel. Furthermore, the most reliable test data are of very limited practical value unless they are so analyzed that the dependence of certain phenomena upon definite factors is clearly revealed.

8 What is needed most is a method of boiler test research which will (*a*) establish a theoretical standard for each partial process and allow the determination of partial and ultimate efficiency, and (*b*) establish the influence of such conditions as variation of specific heat of gases depending upon their composition and temperature, radiation of furnace, variation of efficiency of heat transmission, variation of volume of gases in passages with different conditions of combustion, various rates of firing and percentage of infiltration of air, and influence of superheat on the economy of the process. The graphical method of studying boiler performance as suggested several years ago by Professor Grinevetski, fairly satisfies these requirements, and the diagrams thus obtained, representing the working process of a steam boiler, are the most reliable tools in the hands of an investigator for setting the task for boiler operation independent of the skill of the casual firemen during the test, and plainly establishing the relation between the causes and effects.

9 The Grinevetski method of graphical analysis is one that is particularly useful in showing the interrelations of these important governing variables of the steam boiler. By it the relations between the temperatures of the gases and the heat contained in them at various temperatures are shown in the form of parabolic curves, as

are similarly the relations between the heat in the gases and the area of heating surface, and also the relations of radiated heat to the heating surface. The development of this method of analysis is explained in Appendix No. 1, in which the two examples of the curves (Figs. 13 and 14), namely, for tests Nos. 2 and 6, made at the Warrior Ridge power plant of the Penn Central Light & Power Company, are described. Its application to practice, as outlined

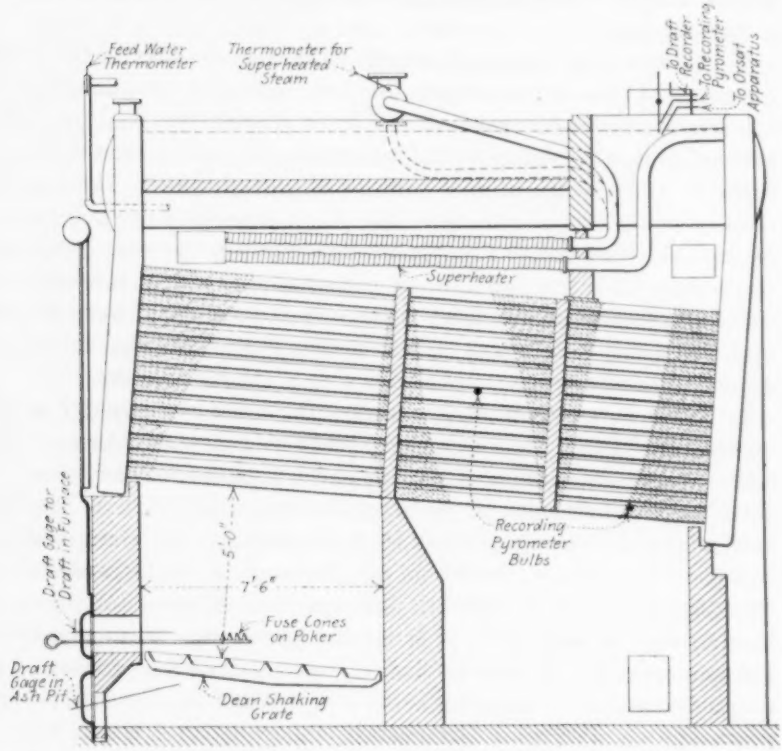


FIG. 1 LONGITUDINAL SECTION OF TEST BOILER SHOWING LOCATIONS OF INSTRUMENTS AND DEAD CORNERS IN GAS PASSAGES

in the following paragraphs, is virtually the basis of the method of work discussed in this paper. The tests referred to above are among a number that were made early in 1913, two of which, tests Nos. 1 and 2 (see Appendix No. 3) were for the purpose of ascertaining the economic result of the operating method in vogue at the plant before betterment work was started and to determine any possible weaknesses of the practice. Test No. 1 is merely a record of obser-

vations made over a period of 80 days to determine the result of former operating conditions, while test No. 2 was a deliberate attempt to make a favorable showing under those conditions. The efficiency observed in test No. 2 was 67.94 per cent. Tests Nos. 3, 5 and 6 were run to study the effects of the various changes made in operating conditions and for the standardization of practice, while test No. 6, which is analyzed graphically in Fig. 14, was a check test on our standard conditions. It showed the efficiency of boilers, furnaces and grates as 76.03 per cent when operating at 89.6 per cent of rating, while its official repetition under a load of 115.5 per cent of rating, showed an efficiency of 77.66 per cent. Tests Nos. 8, 10a and 10b were made principally for the selection of coal.

10 The advantages of graphical study of boiler performance were thus plainly demonstrated and the efficiency figure of 77.66 per cent was accepted as a practical maximum of thermal efficiency for this boiler, furnace and grate. As a method, it demonstrates with an appealing clearness the main conditions and results of the process of combustion and steam generation. As a matter of fact the characteristic curve does not change materially in shape for different boilers nor vary at all for the same boiler and same fuel, and thus the problem resolves itself into mere calculation of scales, shifting of coördinates and measurement of projections.

11 The next question therefore was to ascertain what would be the reasonable limit below which no fireman should allow his efficiency to drop. In this we had to consider the factors beyond the control of firemen, viz.: sudden fluctuation of load and unpracticability in that particular instance to analyze gases every 3 minutes; drop of attention every 40 minutes for the period of 11 to 20 minutes and effect of cooling off heating surface and furnace walls during the cleaning of fires (the allotted time for this was set on time studies as 18 minutes per 100 sq. ft. of grate surface). On the other hand there was made a correction for blowing off the boiler once every 24 hours, which credited the boiler with so much metered water and debited it with so many heat units in the same amount of water at the boiler temperature. As a result of these investigations and studies, it was found that the standard for the task should be set at 70 per cent combined boiler and grate efficiency.

12 In this connection it is interesting to note that all officials of the concern and the representative of the boiler maker, considered the task on this basis too high and that accomplishment of it would be out of the question. The only argument that obtained its tem-

porary approval was that it was easier to reduce the task in the future if not feasible to accomplish than to make it higher. The fourth month of the task work, however, proved that 73.1 per cent of boiler and grate efficiency was permanently maintained, effecting for the company a gross saving of approximately 25 per cent on the fuel bill alone. This was accomplished, and we would like to emphasize the fact, without heavy capital investment for physical improvement of equipment like automatic stokers, special grates, force

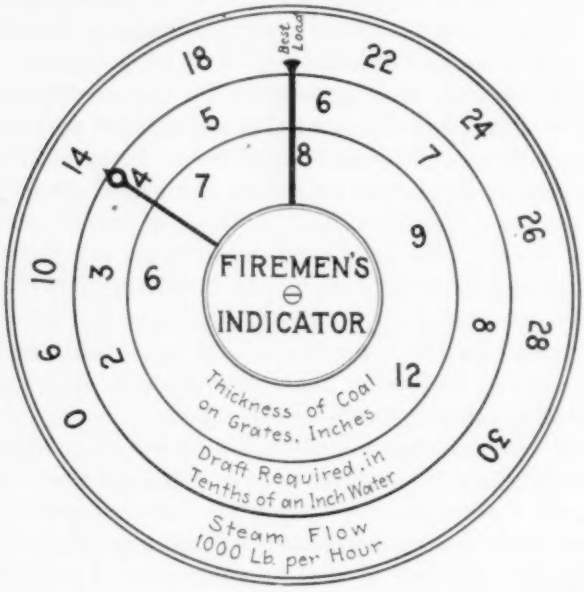


FIG. 2 DIAL OF STEAM FLOW METER WITH SPECIAL SCALES FOR USE AS FIREMAN'S INDICATOR

draft fans, soot blowers, etc. The only expense was for a few instruments for the guidance of the firemen in their work of living up to their instruction card.

13 After the test results were carefully studied and the practical maximum efficiency established, it was an easy matter, by referring to the test logs, to standardize the conditions of firing which necessarily result in generating steam at a desired degree of efficiency. In this, however, difficulty was encountered in that, like the great majority of boiler plants in this country, these boilers were equipped with only pressure gages and water columns, and it was necessary to provide instruments for certain important measurements. As

with other conditions equal, the weight of steam is in direct proportion to the weight of fuel burned, the first instrument necessary for informing the firemen as to how much coal to put in the furnace is a meter indicating the output of the boiler. But as this proportion is constant only at a given condition of combustion, the firemen have to be informed at all times as to what these conditions are. Since complete combustion requires a strictly defined quantity of air per pound of fuel of given composition, we have to know:

a Composition of fuel
b Rate of firing, lb. per sq. ft. per min.
c Rate of air supply, lb. per sq. ft. per min.

In most cases it is possible to obtain fuel of practically uniform analysis, and in addition to have the analysis report within 3 hours from the time of the delivery of coal to the bin, so that the first variable may be taken as a constant. As to the rate of firing, this is indicated by the steam flow meter inasmuch as conditions of combustion are uniform. Then, our last variable, the quantity of air to be supplied per minute to the furnace, is the factor which we have to control.

14 As long as the infiltration of air remains constant (it should be as near to zero as possible) and the cross-section of air ducts or pit doors is constant, the variable elements are the velocity of air and its specific weight. The specific weight being a function of temperature, calls probably for not more than two corrections per year for winter and summer average temperatures in the fire room. Thus we have a practical solution of the problem in the indications of a draft gage. Draft, i. e. vacuum over fires, is usually measured in such small fractions of an inch of water column that, considering the resistance of flow of the gases through the boiler as constant for each rate of firing, it is more convenient to take readings at the uptake. From our definition of the draft as vacuum, it follows that, in itself, it is no indication as to quantity of air flowing through the fuel bed and must always be considered in relation to the resistance offered by the layer of burning coal. Careful tests can easily establish the desired interrelation between the quantity of air and thickness of fires, or a duplex draft gage can be advantageously used.

15 This reasoning leads to the conclusion that for practical guidance the fireman needs at least three instruments:

a Indicating steam meter
b Draft gage

c Indicator for the coördination of the condition of firing with the load carried by the boiler at any moment.

In his experience the writer found that the well-known General Electric steam flow meter of the indicating type could easily and satisfactorily serve the third mentioned purpose. The writer arranges on the dial of the steam flow meter an inside dial, as shown in Fig. 2, with numbers indicating the required thickness of fuel bed corres-

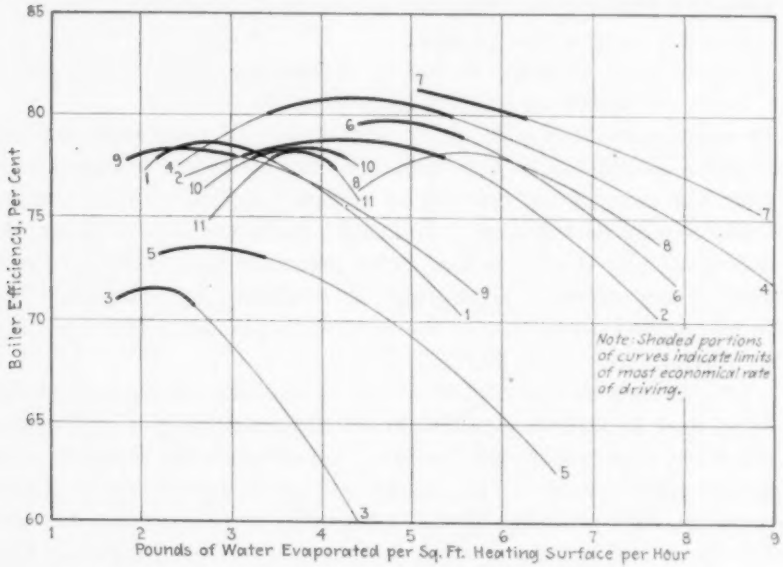


FIG. 3 DIAGRAM SHOWING MOST ECONOMIC LOADINGS FOR VARIOUS TYPES OF BOILERS

ponding to the number of pounds of steam drawn from the boiler and a third dial with numbers indicating the draft which is necessary and sufficient to supply the required quantity of air for the combustion at a rate called for by the indicated steam demand. Thus, if the pointer, as in Fig. 2, shows that steam is flowing from the boiler at a rate of say 14,000 lb. per hour, the fireman will know that the figure 4 under the pointer on the middle scale means that a draft of 0.4 in. of water is needed and that the location of the pointer on the inner scale between the figures 6 and 7 calls for a thickness of fires of from 6 to 7 in.

16 The next information vitally important for the fireman is the frequency at which his furnace must be coaled to keep the fires in best condition. The method adopted by the Italian Navy is accepted by the writer as most satisfactory, consisting chiefly in bell signaling at intervals in proportion to the load carried by the boilers, which signaling is regulated by clock mechanism connected with a flow meter. For use in a boiler house where a number of batteries are fired independently and it was desirable to eliminate the variations of load among them, a modification of this method was devised to equalize the driving of each furnace. For this purpose the counter of the feedwater weigher, supplying water to the entire boiler house, rings the bell every time a certain number of thousand pounds of water is fed to the boilers, thus giving notice to the firemen that an adequate number of shovelsful must be thrown into each furnace. This number is easily determined since the weight of a shovelful of coal is known and the rate of apparent evaporation at the given condition of firing is a constant.

17 In a public utility plant the load carried by the boilers varies considerably, as a rule, not only throughout a day but often within an hour, in which it may swing from maximum to minimum, or vice versa. This condition was particularly noticeable in the plant of the Penn Central Light & Power Company at Warrior Ridge, Pa., supplying power to the consumers as different in character as residential lighting, coal mines, textile mills, quarries and interurban railroads. While with a number of small steam generating units the peak periods and off-peak valleys in the load curve do not affect the rate of driving individual boilers since the number of boilers put into service can easily be changed, a widely fluctuating load within a short period has its limiting influence on the attainable efficiency of steam generation. The time element in boiler performance, or, in other words, the time required for generation of a certain quantity of steam with the greatest economy, is of utmost importance. Some idea of the relation of factor of thermal efficiency to the rate of driving for boilers of different designs is given in Fig. 3, a chart compiled from data gathered from the experience of the writer.

18 Here again we are confronted with the fact that the thermal efficiency is not a final criterion and it is often the case that high rate of driving, although thermally efficient, is too expensive on account of special costly devices necessary for forcing the boilers or uneven distribution of work on the men requiring extra men idle part of the time. Unwarranted fixed charges in one case and a high

pay roll in the other make it financially desirable to limit the output of the boilers. Again, in other cases low rates of driving are abandoned irrespective of the thermodynamic advantages on the strength of financial impossibility for the concern to add new units.

19 The above considerations require for proper solution of the problem a scrupulous research into interdependence of: (*a*) Variation of fixed charges with various time units required for production of a unit of volume energy in shape of steam; (*b*) variations of thermal efficiency with the variations of the above time unit; (*c*) variations of pay roll, etc.; (*d*) variations of the cost of maintenance, etc.; (*e*) physical limits affecting the quality of steam, as size of superheaters which at certain point are unable to absorb the heat due to slow convection of heat by dry steam; and (*f*) physical limits of space. Thus, while the increase of output up to certain limit usually increases the thermal efficiency, after this point it begins to fall. But it is in most cases erroneous to assume this maximum efficiency point as a best load to operate the boilers at, due to the complexity of the above mentioned limiting factors.

20 From this short reference to the limiting influence of the variable factors on the final commercial economy we may pass to the problem of final criterion for the determination of the task. The process of steam generation can be conveniently represented in the form of the equation:

$$E_s = E_f \times E_p \times E_m \times E_g \times E_c \times E_t$$

where E indicates the ratio of utilization, or efficiency, and the corresponding indexes signify as follows: s steam generation, f financial outlay, p purchase of fuel, etc., m attendance of men, g gasification of fuel in furnace, c combustion of gases, and t transmission of heat of gases to the boiler water and steam.

21 In a given plant E_f is constant; E_p is to be determined previous to the setting of the task for men; the quality, characteristics and cost of fuel are so strictly governed by the construction of the furnace and boiler, by the available draft, and methods of stoking by the coking or baking peculiarities of fuel, that from the few varieties of fuel available on the market, the selection of the most suitable is a mere computation of the cost of fuel for generating say 1000 lb. of steam of given quality. This computation, however, shall follow, not precede the determination of the best condition of combustion with each of the varieties of fuel permanently available on the local market at a given cost including freight rates.

22 Efficiency of gasification of fuel E_g is a variable which in its

turn is limited by: (*a*) rate of firing, (*b*) fusing and clinkering quality, (*c*) size of fragments of fuel, (*d*) method of firing, (*e*) frequency of leveling or shaking, and (*f*) thickness of coal bed (provided the design of furnace or grates remains unchanged).

23 Similarly E_c, efficiency of combustion of gases liberated from the fuel, is limited by several factors: (*a*) composition and nature of volatile matters, (*b*) proportion of gases to oxygen supplied by air, (*c*) volume of gases developed per unit of time, (*d*) velocity of gas currents, (*e*) volume of furnace, (*f*) distance of the combustion zone from the heating surface, and (*g*) thickness of fuel bed, or length and shape of torch (for gaseous and liquid fuels).

24 Finally E_t, efficiency of transmission of heat, even in the boiler of a given design, varies widely and is positively determined by: (*a*) velocity of hot gases, (*b*) volume per unit of time intact with unit of area, (*c*) temperature of the gases, (*d*) pressure inside of the boiler, (*e*) insulating coating of cool gases, soot and scale deposits, and (*f*) desired quality of steam.

25 A method of computing these partial efficiencies is self-evident:

$$E_g \text{ (efficiency of gasification)} = \frac{\text{heat value in refuse from N lb. coal burned}}{\text{heat value in N lb. of coal}}$$

$$E_c \text{ (efficiency of combustion)} = \frac{\text{heat developed, computed from gas analysis}}{\text{heat in fuel less heat in refuse}}$$

$$E_t \text{ (efficiency of heat transmission)} = \frac{\text{heat in steam generated by 1 lb. fuel}}{\text{heat available for heating surface}}$$

In the last case the temperature of the boiler itself at the given pressure could be taken into consideration as well as the temperature required for the creation of draft. In other terms this equation can be represented as the function of temperatures.

$$E_t = \frac{T - t_s}{T - t_k}$$

where

T = temperature of the gases of combustion
t_s = temperature of gases leaving boiler at uptake
t_k = temperature of boiler water

26 The information these formulae convey is of the greatest importance for influence of judgment as to what partial efficiency and to what extent it could be sacrificed in order to arrive at a desired high standard and meet all other practical requirements and conditions. But, it must not be forgotten that they contain no time ele-

ment in their composition. To introduce this criterion the boiler output per hour shall be recognized in either of the methods:

$$\text{thermal boiler horsepower} = \frac{\text{heat absorbed by boiler per hour}}{1{,}980{,}000 \text{ ft-lb.}}$$

or

$$\text{mechanical boiler horsepower} = \frac{p \times v}{23{,}760{,}000}$$

where

p = steam pressure absolute per sq. in.
v = steam volume generated in cu. in. per hour

27 This general outline of a method of analyzing the limiting values of variables and determination of conditions necessary for the attainment of certain predetermined results would be incomplete without a reference to the practice of studying the influence of individual variables. The writer is convinced that any boiler trial conducted with the most scrupulous care may leave obscure the influence of a number of the above mentioned limiting factors as well as leave the question uncertain whether the maximum practical efficiency or capacity was really obtained during the test and whether or not the various conditions as observed are necessary and sufficient to duplicate the results at any time. The writer maintains, that as long as the question is not to attain accidentally a mark set at random, but clearly and fully to determine all conditions necessary for maximum economy of operation, for the purpose of setting definite standards, it is imperative to conduct a number of separate observations, though of short duration, dealing in each case with one and only one variable in order to find its limiting effects. Only through an a posteriori method of reasoning, through a wide induction from a sufficient number of particular observations, may the probability that is tantamount to certainty be attained.

28 Ascertaining finally the physical elements of the efficiency equation and its value and, eliminating the constants beyond our control, we ultimately obtain a reliable basis for judging the efficiency of the "human element" of the problem which could be expressed as

$$E_m = f(e)$$

and its limit is reached when the difference between the theoretical efficiency of the process and its actual accomplishment is zero.

29 We now come to the question of how to use this available knowledge based on theoretical research in such a way as to secure the best results practicable in regular service by the task method.

In setting a task for firemen, it remains to be determined what the scope of the task shall be. In order to accomplish the purpose it devolves upon the management to accumulate the detailed and exact knowledge of the most favorable conditions to attain results and make it possible and desirable for every employee to live up to them. It is for the employee, on the other hand, either to create or maintain such conditions as are required in the management's specific instructions.

30 Various schemes have been used as the basis of task setting for firemen which to the writer's knowledge have always created dissatisfaction. Certain of these are as follows:

a The cost of steam generated was used for the basis of the task in the boiler room of a large cement plant, and a premium offered for the reduction of this cost, but as firemen have no control over the purchase of fuel, maintenance of equipment, etc., this task involved the standardizing of conditions of combustion, for which no instruments were provided and no definite standard or aim was set before them, and the scheme was soon abandoned.

b The high percentage of CO_2 in flue gas was adopted as a task basis for firemen in several plants, but the men were not trained nor were they even shown how to obtain it. When they occasionally attained the mark, the question remained undecided whether high percentage of carbon dioxide was coincident with the most economical steam generation or not, and the method proved generally unsatisfactory.

c A high percentage of CO_2 and low percentage of combustible in the ashes, were factors upon which another attempt was made to specify more definitely the firemen's task. The question remains, however, whether the conditions which the firemen must observe to attain the task and produce gas rich in carbon dioxide and an ash with little carbon, are actually the best for transmitting the heat of the gases to the water and steam and whether at any load the same standard is equally beneficial.

d A limit on coal consumption as a task for railroad firemen was favored at one time. This idea, probably the most ridiculous and illogical, soon demonstrated its own weakness and has been almost entirely abandoned.

31 The lack of analytic thought in these instances is remarkable; such important factors as condition of equipment, variable quality of fuel, weather conditions, necessary instruments, complete record keeping, thorough instructions, etc., were disregarded or undervalued. The common cause of failure of such schemes has been the desire to make a short cut and jump over all preliminary studies, and save the time and trouble of training men in a systematic and thorough manner how to accomplish the task set for them. Should such training be undertaken with bona fide intentions, the instructors themselves would be compelled to discontinue the training as soon as they discovered that the control of the conditions affecting the results is beyond the men.

32 The question of measuring the effect of task accomplishment can be approached from either end, but it is more convenient to figure out the result, and if this is below the standard, turn to the records of conditions and there locate the discrepancy between the required results and those obtained. A gage for measurement of the degree of fulfilment of task conditions set is offered by the factor of thermal efficiency of grate, furnace and boiler which is

$$\frac{\text{heat transferred to steam}}{\text{heat available in fuel}}$$

This measurement involves several corrections for factors beyond firemen's control and neither ratio of apparent evaporation nor boiler efficiency nor efficiency of combustion alone are anywhere near sufficient for the purpose of judging the efficiency of the work of men.

33 Actually to calculate the efficiency of the boiler, furnace and grate is a tedious and comparatively long procedure, and is never made in power plants for a day, shift, fireman or gang of firemen working in team. The writer in his capacity of consulting engineer devised and introduced a comparatively simple method of obtaining a complete record of firemen's performance and to figure their efficiency. This method, which has been in vogue for over a year at the central station at Warrior Ridge, Pa., requires the following record data:

a Coal records from store issue tickets and coal passers reports compiled every eight hours

b Heat value of fuel determined by bomb calorimeter and value of coal in B.t.u. known for each coal pocket

c Amount of water fed to boiler (banked boilers fed separately) ascertained for the same periods

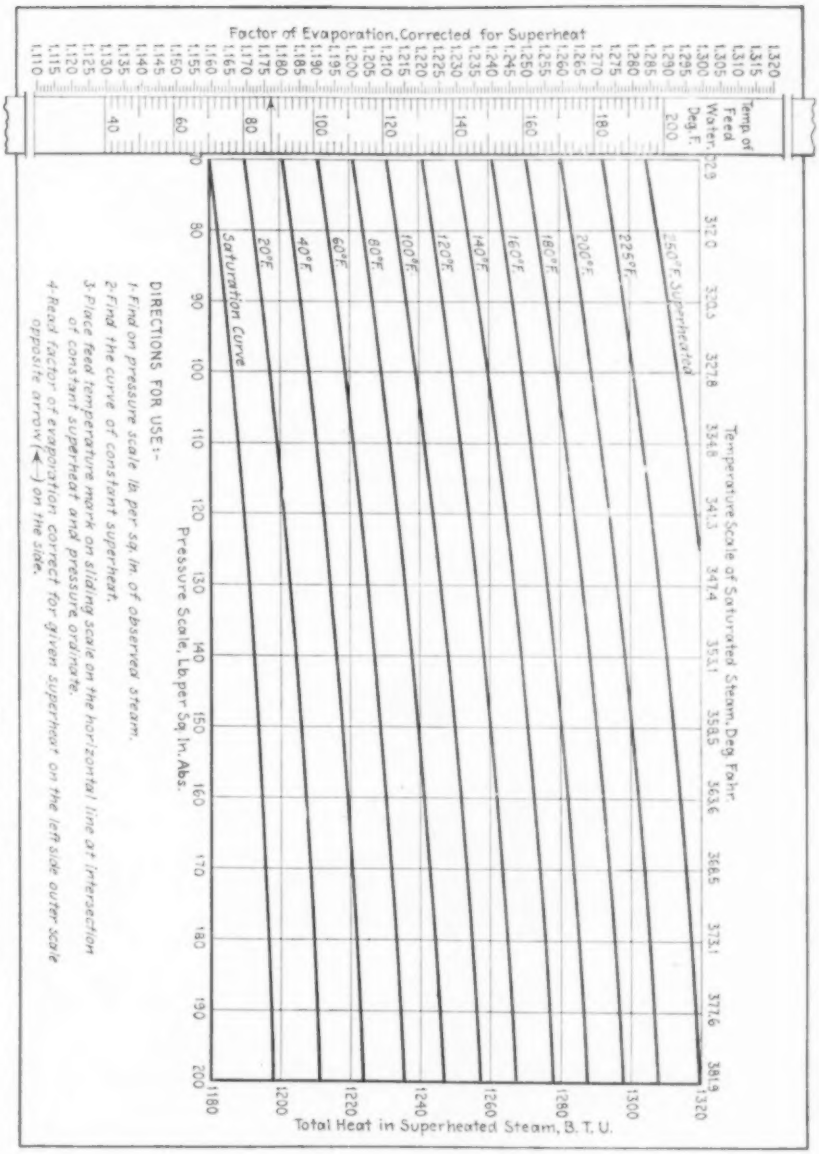

Factor of Evaporation, Corrected for Superheat
Temp. of Feed Water, Deg. F.
Temperature Scale of Saturated Steam, Deg Fahr.
Pressure Scale, Lb. per Sq. In. Abs.
Total Heat in Superheated Steam, B. T. U.
Saturation Curve
20°F
40°F
60°F
80°F
100°F
120°F
140°F
160°F
180°F
200°F
225°F
250°F Superheated
DIRECTIONS FOR USE:-
1- Find on pressure scale (lb. per sq. in. of observed steam.
2- Find the curve of constant superheat.
3- Place feed temperature mark on sliding scale on the horizontal line at intersection of constant superheat and pressure ordinate.
4- Read factor of evaporation correct for given superheat on the left side outer scale opposite arrow (▲) on the side.

FIG. 4 SLIDE RULE USED FOR DETERMINATION OF FACTORS OF CORRECTION

d Temperature of feedwater recorded
e Steam pressure recorded
f Degrees of superheat recorded

34 These data are turned over to the station clerk who proceeds as follows:

a From the slide rule shown in Fig. 4, he ascertains the factor of evaporation (corrected) on the basis of absolute boiler pressure, temperature of feed and temperature of superheat

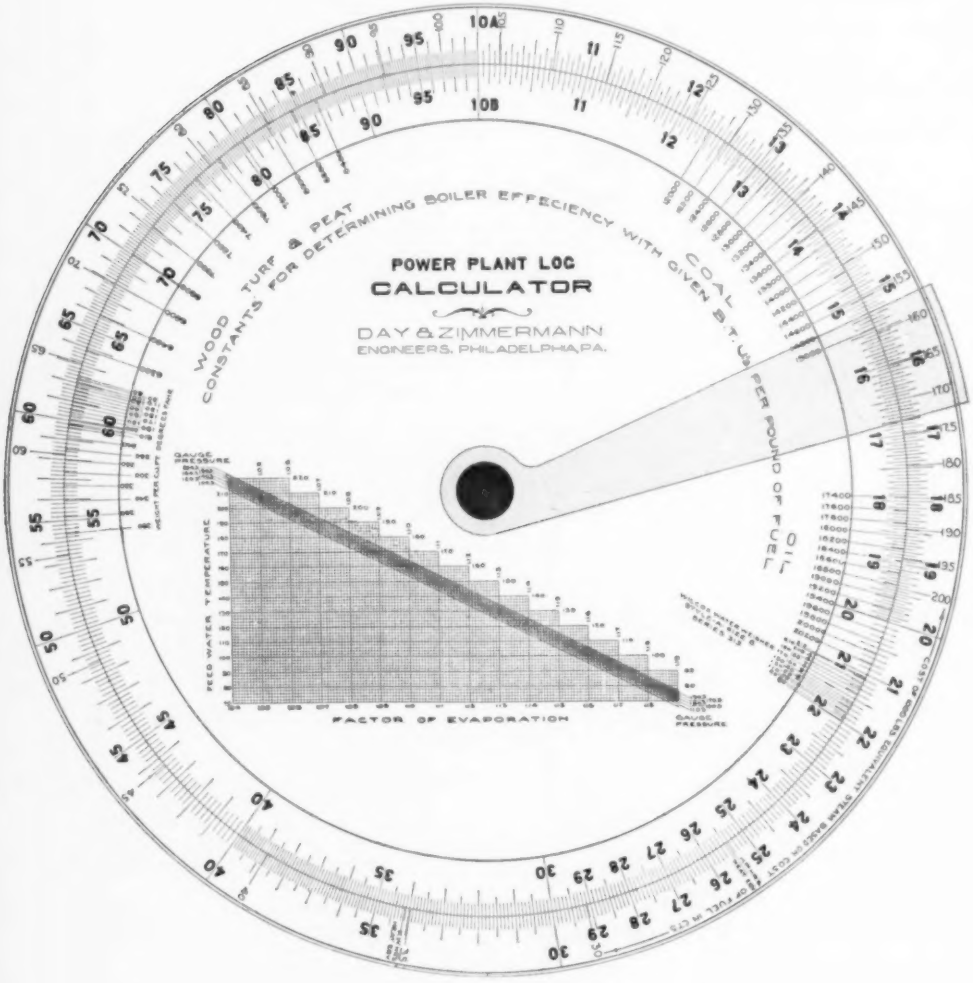


FIG. 5 POWER PLANT LOG CALCULATOR

b By means of the power plant log calculator, Fig. 5, he determines

1 actual evaporation ratio during each watch or per each man

2 factor of evaporation during each watch or per each man

9	6	19/3
MONTH	DAY	YEAR

I HAVE INVESTIGATED AND REPORT BELOW THE CAUSE OF LOST BONUS

DEPT. Electr.
DISTR. War. Ridge

BY O. Hawn ON JOB Firing

CONDITION Draft was set wrong
Due to leak in draft gauge

RESPONSIBILITY IS ALLOCATED TO Maintenance Man

REMEDY ATTENDED TO BY ME Ordering Repair

S. D. Port
SIGNED

9	12	19/3
MONTH	DAY	YEAR

I HAVE INVESTIGATED AND REPORT BELOW THE CAUSE OF LOST BONUS

DEPT. Electr
DISTR. War. Ridge

BY D. M. Pope ON JOB Firing

CONDITION Extra boilers were shut down after midnight.
Unexpected load came, too high rate of firing.

RESPONSIBILITY IS ALLOCATED TO Switch-board operator

REMEDY ATTENDED TO BY ME Reprimanded

S. D. Port
SIGNED

FIG. 6 EXAMPLES OF FORM USED FOR RECORDS OF CAUSE OF LOST BONUS

3 equivalent evaporation during each watch or per each man

4 efficiency of steam generation per watch or per each man

5 cost of fuel per 1000 lb. of steam per watch or per each man

He then enters the results of computation on the daily power plant

report form (see Figs. 11 and 12). The whole procedure takes on the average 18 minutes of the clerk's time, for whom, incidentally a specific task is assigned and sufficient hourly bonus offered for, its fulfilment.

35 Every case of failure on the part of any fireman to secure on his watch the combined boiler, furnace and grate efficiency of 70 per cent or above is immediately investigated by studies of other records and recording charts of draft, temperature of escaping gases, nature of boiler refuse, etc., and if no reason can be found there, an exam-

FORM 64661A

DAILY BONUS SLIP CHARGE

DATE September

NAME J. Dearing NO.

DISTRICT - PLANT Warrior Ridge

HOURS DAY WORK	4
HOURS BONUS WORK	4
HOURS BONUS EARNED	1
TOTAL HOURS FOR DAY	9

REMARKS 71.8% - 4 hrs. firing on 3rd shift,
4 hrs. passing coal for sick coal passer.

SIGNED S. D. Port

FIG. 7 FORM FOR DAILY BONUS STATEMENT TO FIREMEN

ination of the physical condition of equipment and apparatus is made. The result of this investigation is recorded on a form for cause of lost bonus, Fig. 6. This method is particularly valuable and outside of its direct advantages provides an additional and continuous training of the men in careful observation of harmful factors of the slightest nature.

36 Then by means of complete and trustworthy records the firemen are informed as to results of their work before they come back for the next watch, see Fig. 7, and moreover, while they are proceeding with their work, they have in addition to previously mentioned instruments indicating the condition of firing, continuous information as to results they are accomplishing up to any moment of their watch. This is accomplished by having coal weighing and water metering so balanced that an even number of dumps of feedwater

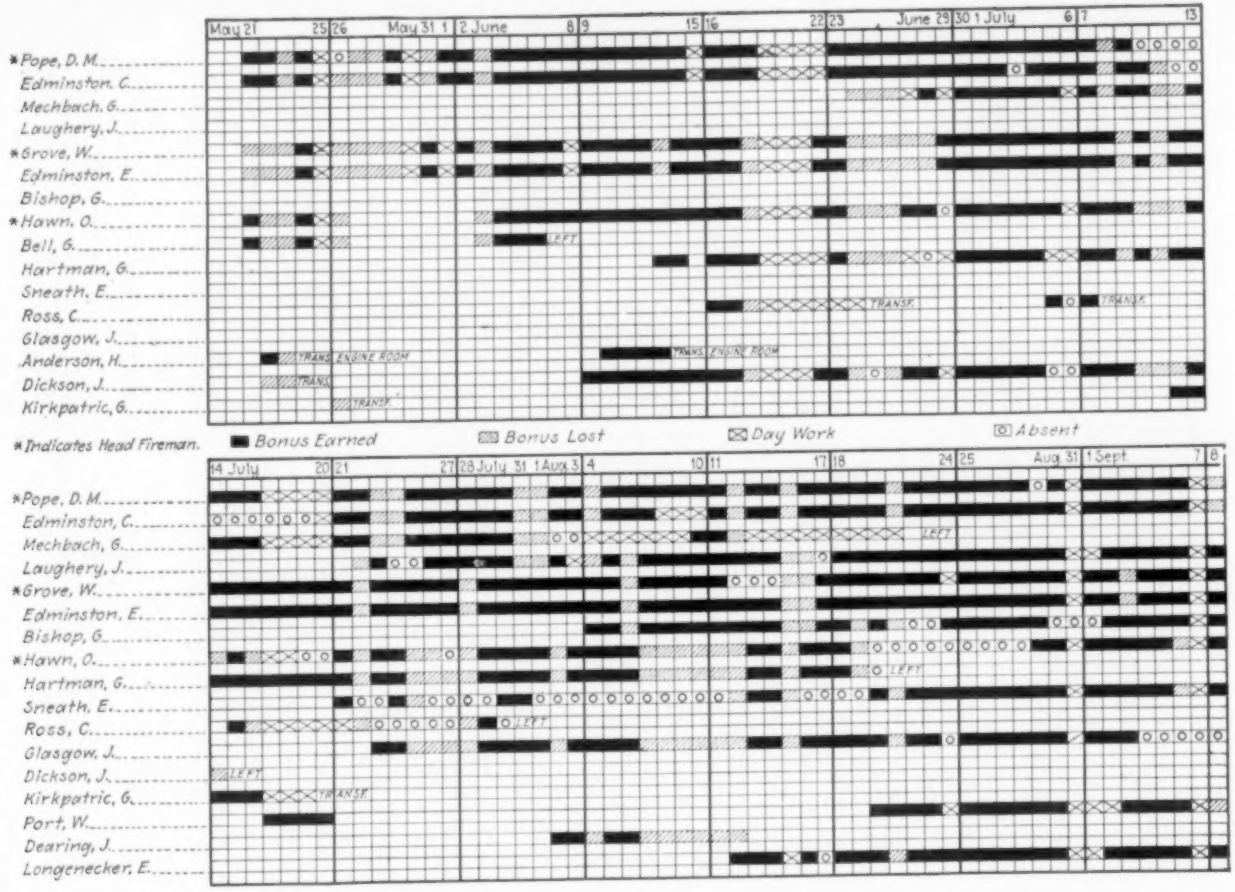


FIG. 8 FORM OF GRAPHICAL BONUS RECORD IN USE

and dumps of coal indicates that the ratio of evaporation (superheat, pressure and feed temperature being as specified), is on the safe side of the requirement.

37 The record of attainment of the task by firemen kept in the manner devised by H. L. Gantt, Fig. 8, offers such well-known advantages over any other method that it was adopted for general use by the above mentioned public utility companies. The illustration of this record, kept from the start of task work in the boiler house at Warrior Ridge of the Penn Central Light & Power Company, shows steady improvement and better habits of men. While the May record showed only 68.7 per cent efficiency of boiler and grates of the whole plant, the last month on this record showed the efficiency of 73.1 per cent. The number of day-men falling short on the task is steadily reducing. The number of men absent is, however, chiefly due to "days off" and summer vacations for the men work seven days a week in a plant of this character. It should here be stated that the departure from the principle of separate man's record made by the writer at first involuntarily proved to be so gratifying, creating as it did an unusually strong team spirit of coöperation, that the writer has never attempted to split the records of two or three men working jointly firing one battery of boilers.

38 The elements affecting the choice for or against task work are so numerous that they cannot all be mentioned. The essential thing is that some element of advantage to the workman be introduced sufficient to overcome actual or imaginary disadvantages believed by the men to exist as a result of the new state of affairs. This advantage takes the form of a sufficiently attractive and generous bonus to be paid for willingness to learn the new way and to continue to observe the instructions. Actual accomplishment of the task and consequent earning of the bonus means the adjustment of certain conditions concurrent with the adjustment of others. This adjustment being under the control of the employee is a physiological process principally depending on (*a*) the willpower of the man, and (*b*) physical fitness.

39 The man for whom a certain task is assigned must strive to accomplish its aim. The exercising of the power of will is a threefold process: first, the man must have a desire; secondly, he must make a choice of ways and means; and thirdly, he must perform necessary actions. The workman's desire from necessity is to earn his living at least; next he has to choose whether he shall work under instructions as set forth in the standing order and instruction cards for the

compensation offered; and lastly, he has to act according to his decision in order to satisfy his desire.

40 As a rule, the workmen feel that the adoption of a new method will impose an undue strain, but it is comparatively easy to overcome this misconception with the firemen from the fact that greater efficiency means less coal to be shoveled. On the other hand, the new conditions require the men to give their attention to instructions and the indications of the apparatus, which diverts them unpleasantly from chatting at leisure with their fellow workmen. This forms a more serious obstacle to their quick decision in favor of new routine than anything else.

41 Cases are not infrequent where the men, particularly those more or less in authority, take offense at scientific study and prefer to fight it or even quit rather than admit the advantages of the new practice. Temperament usually determines the vigor of the opposition. Social conditions occasionally influence a man's choice for or against the new regime. If a person who is admired by his associates happens to decide against task work, he is liable to influence the choice of his friends and acquaintances very materially. Members of labor unions are more apt to disfavor task work, while socialists are strongly in favor of it, feeling that the scientific method of management helps to solve the problem of nationalization of industries.

42 In order to determine the amount of bonus, there must be two limits established—a maximum and a minimum. The maximum bonus should be equal to the amount of net saving accomplished under given circumstances, while the minimum bonus is, of course, equal to zero. When the bonus to be paid actually reaches either of these limits it loses its usefulness since it loses its stimulating effect—with the management, if the maximum, and with the men, if the minimum. Since in an average boiler house the task results in about 25 per cent saving on the coal bill while the fireman's pay roll is from 10 to 15 per cent of the coal bill, it is evident that there is a considerable latitude for adjustment of bonus.

43 After the choice has been made in favor of task work, however, as a result of the stimulus offered, the third element, proper action, is yet far from being secured. To act in the chosen direction one must know how the desired result is to be accomplished. Lack of sufficient information necessarily produces a strong perception of uncertainty coincident with suffering. After the excellent essay on training workmen by Mr. H. L. Gantt, little if anything can be said

on this subject except, that in case of firemen, the success of attainment of the task is determined by detailed, patient, and prolonged training and instructions, and as such this is the most important function of the management. A dummy furnace was found to be an excellent means to break in the green hands.

44 Although the above requirements of additional compensation and exhaustive training for stimulating men's will to coöperate with the management in attainment of the state of high efficiency are imperative, they alone are insufficient. The psychical conditions

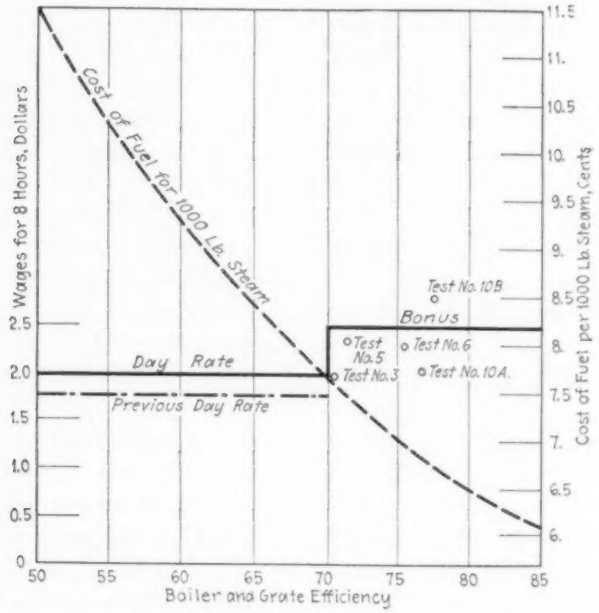


FIG. 9 DIAGRAM SHOWING METHOD OF TASK AND BONUS ADJUSTMENT

under which the men have to work must be so arranged as to insure the fullest preservation of their strength, health, and psychical faculties. The opposition exercised by some labor organizations in instances where greater efficiency is demanded from the workingmen without adequate safeguards to their vitality and ability to work is a just and well grounded fight against the short-sightedness of some self-termed efficiency experts.

45 In a boiler house the amount of work per man per hour is constant, and cannot be increased without knocking down the efficiency to a ridiculously low figure, but the number of foot-pounds of

work can be reduced in an inverse proportion to the increase of efficiency, so that the question of preservation of a man's health, etc., eliminates any consideration of overspeeding. The conditions which then remain for consideration are (*a*) temperature of room; (*b*) ventilation (dust and draft); (*c*) lighting; (*d*) drinking water; (*e*) restful seats; and (*f*) sanitary washrooms.

46 One familiar with the common layout of a power plant cannot over-emphasize the importance of the above conditions to enable the men to live up to their task day in and day out. While engine rooms not infrequently offer very pleasant and sanitary surroundings, boiler houses, the most important part of any plant, are so built as to make them unbearably cold in winter and uncomfortably hot during the summer; ventilation apparently serves either to fill the lungs with coal dust or to chill the perspiring men after cleaning their fires. Lighting is an unusual luxury, so that after looking into the furnace no man could read his gages or examine anything around the boiler. Good drinking water is rarely provided, and restful seats with backs (seats without backs are equal to no seat at all) were never found by the writer in any boiler house. Yet the mere fact that the firemen, if provided with seats having backs, can get through the cleaning of fires in 18 minutes per 100 sq. ft., while without them they consume at best 24 minutes, apparently should convince any unbiased mind.

47 On the contrary, the absence of an elementary condition of comfort in a working place where the men spend the better part of their lives is more harmful to the employers than to the employee. The petty annoyances and feelings of discomfort divert the attention of the men from the performance of their duty to means of avoiding the annoyance or harm. Steady attention on the part of the fireman is much more important than is generally realized. A psychological test conducted by the writer on the effect of the occasional drop of attention with the same individual and with individuals possessing different degrees of this faculty proved that *physical condition and strength being constant, the boiler efficiency percentage is in an almost direct proportion to the degree of attentiveness of the fireman.*

48 With healthy, sanitary and pleasant surroundings as a sufficient criterion for judging whether the man's task is harmful, a simple and apparently reliable method was devised by the writer. It is evidently beyond the means of ordinary time study to define whether or not the possible output in a unit of time is a safe one from the viewpoint of the preservation of the individual and the

nation. The problem in itself is twofold: (*a*) strain per unit of time in foot-pound per square inch of cross-section of a muscle, and (*b*) number of time units at work. As in every case where more than two variables are evolved the maxima are determined by the limiting conditions of variables, and the constant safe limit can be reached either by a comparatively great strain during a short time or a less

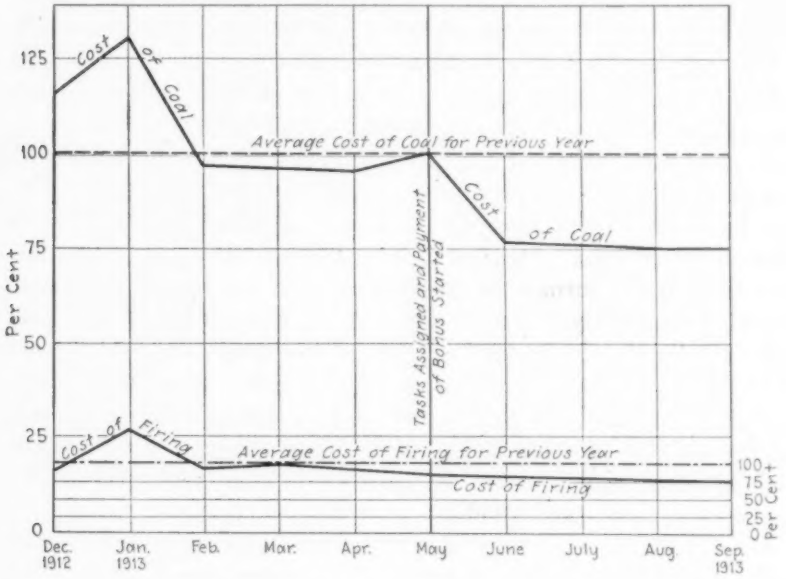


FIG. 10 GRAPHICAL RECORD OF ACTUAL REDUCTION OF COST OF COAL AND LABOR PER KILOWATT-HOUR

intense strain during a longer period. If t and s are time and strain respectively, the equation

$$\frac{d}{d}\left(\frac{ct \times s}{t \times c's}\right) = 1,$$

if differentiated, illustrates the problem; yet, whether factor c for time or c' for strain has the same numerical value the experiments alone are able to show. More study along this line is needed.

49 In our experience we adopted in addition to time studies, a careful investigation of fatigue, both mental and physical, and measurements of the vitality of the men affected by various conditions of work and number of working hours per day. No task is reasonable unless the workman can fully regain his loss between quitting time and recommencing work the next day, and during a sufficiently

long period of observation a man should be able to gain or at least not lose anything in his vitality. Observations should cover at least four factors: (*a*) weight of body; (*b*) blood pressure; (*c*) temperature of body; and (*d*) pulse. The blood analysis while considered desirable is too cumbersome to make, and other indications being favorable can safely be omitted. Almost unanimous statements of those observing the task work performed in a great variety of industries assert that men are gaining in health and spirit, but scientifically definite data alone could prove this fact beyond any doubt.

50 Finally, the time element in relation to task setting for men,

DAILY POWER PLANT REPORT

PENN CENTRAL LIGHT AND POWER CO.
STATION Warrior Ridge

FOR 24 HOURS ENDING: MONTH 9 | DAY 14 | YEAR '13 | HOUR 7 A.M.

BOILER ROOM	WATCH 1	WATCH 2	WATCH 3	ENGINE ROOM	WATCH A	WATCH B	WATCH C
COAL USED (tonnage)	48800	49200	34000	HYDRO ELECTRIC OUTPUT	980	850	30
WATER EVAPORATED	413800	408200	284000	STEAM GENERATED OUTPUT	21220	20450	15070
ACTUAL EVAPORATION	8.62	8.32	8.37	LOAD FACTOR	79.5	64.4	67.5
FACTOR OF EVAPORATION	1.2187	1.2185	1.2287	STEAM PER KWH	19.78	20.00	18.85
EQUIVALENT EVAPORATION	10.50	10.13	10.28	COAL PER KWH	2.30	2.40	2.26
EFFICIENCY OF GENERATION	73.4%	70.8%	71.8%	THERMAL EFF-CY. OF PLANT	10.71	10.27	10.73
COST OF FUEL PER 1000 LBS. OF STEAM	0.0815	0.0845	0.0833	COST OF FUEL PER KWH (including overhead)	0.00201	0.00204	0.00200

REMARKS:

COAL USED FOR BANKING 1 " BOILERS DURING 6 9 HRS 55 30 MIN. 3000 LBS. COAL ANALYSIS BTU AVE B.T.U. 13900

TOTAL OUTPUT _____ KW HRS. THIS REPORT IS A TRUE AND CORRECT SUMMARY OF RECORDS KEPT BY ME. S. D. Port SIGNED

FIG. 11 EXAMPLE OF DAILY REPORT FROM THE PLANT SHOWING AVERAGE RESULTS

particularly if the work requires a considerable strain, must be settled by examination no less careful than the study of the time rate of driving boilers. When, however, as in the case of firemen, both physical strain and attention are required, it was found that with strong, healthy individuals the limiting factor on number of hours of profitable work is set not by physical exhaustion but by weariness of spirit. *Other conditions being equal, a fireman on a 12-hour watch is found to be about 4.5 per cent less efficient than the same man on an 8-hour shift.*

51 This time-limiting factor on human efficiency, taken in conjunction with a scientific certainty in determination of the most advantageous thermal efficiency, formed the grounds on which the

writer rejected the sliding scale of bonus rate results exceeding the task set by various degrees. The task set must be so little below the

DAILY POWER PLANT REPORT

PENN CENTRAL LIGHT AND POWER CO.
STATION Warrior Ridge — FOR 24 HOURS ENDING 9 (month) 6 (day) 13 (year) 7-- (hour)

BOILER ROOM	WATCH 1	WATCH 2	WATCH 3	ENGINE ROOM	WATCH A	WATCH B	WATCH C
COAL USED (spoiling excluded)	52000	50000	31900	HYDRO ELECTRIC OUTPUT	1300	2240	60
WATER EVAPORATED	449000	430000	265500	STEAM GENERATED OUTPUT	22700	22560	14840
ACTUAL EVAPORATION	8.66	8.62	8.35	LOAD FACTOR	88.5	68.3	62.1
FACTOR OF EVAPORATION	1.2125	1.2159	1.2051	STEAM PER KWH	19.78	19.07	18.00
EQUIVALENT EVAPORATION	10.49	10.48	10.05	COAL PER KWH	2.29	2.21	2.15
EFFICIENCY OF GENERATION	73.9	73.8	70.8	THERMAL EFF-CY. OF PLANT	10.85	11.22	11.54
COST OF FUEL PER 1000 LBS. OF STEAM	0.0823	0.0814	0.0848	COST OF FUEL PER KWH (including spoiling)	0.00198	0.00189	0.00206

REMARKS:

COAL USED FOR BANKING 1 " BOILERS DURING 6 8 HRS. 55 40 MIN. 5000 LBS. COAL ANALYSIS BTU AVE. B.T.U. 13800

TOTAL OUTPUT _____ KW HRS. THE ABOVE IS A TRUE AND CORRECT SUMMARY OF RECORDS KEPT BY ME. S. D. Port SIGNED

DAILY POWER PLANT REPORT

PENN CENTRAL LIGHT AND POWER CO.
STATION Warrior Ridge — FOR 24 HOURS ENDING 9 (month) 7 (day) 13 (year) 7-- (hour)

BOILER ROOM	WATCH 1	WATCH 2	WATCH 3	ENGINE ROOM	WATCH A	WATCH B	WATCH C
COAL USED (spoiling excluded)	51850	54000	30750	HYDRO ELECTRIC OUTPUT	530	4890	
WATER EVAPORATED	436600	423000	260500	STEAM GENERATED OUTPUT	22470	22310	13400
ACTUAL EVAPORATION	8.43	7.85	8.50	LOAD FACTOR	78.3	74.4	55.8
FACTOR OF EVAPORATION	1.2125	1.2095	1.1965	STEAM PER KWH	19.43	18.99	19.46
EQUIVALENT EVAPORATION	10.22	9.49	10.17	COAL PER KWH	2.31	2.42	2.80
EFFICIENCY OF GENERATION	71.8%	66.7%	71.5%	THERMAL EFF-CY. OF PLANT	10.72	10.26	10.80
COST OF FUEL PER 1000 LBS. OF STEAM	0.0837	0.0900	0.0840	COST OF FUEL PER KWH (including spoiling)	0.00196	0.00205	0.00208

REMARKS:

COAL USED FOR BANKING 1 " BOILERS DURING 7 8 HRS. 05 43 MIN. 2000 LBS. COAL ANALYSIS BTU AVE. B.T.U. 13800

TOTAL OUTPUT _____ KW HRS. THE ABOVE IS A TRUE AND CORRECT SUMMARY OF RECORDS KEPT BY ME. S. D. Port SIGNED

FIG. 12 DAILY REPORTS SHOWING HIGH AND LOW AVERAGE RESULTS FROM THE PLANT

most advantageous point that it could be reached with greatest benefit to all concerned and it is not desirable from economical aspects either to fall short of or considerably to overreach it. Offer-

ing extra compensation for excess of the task requirement means in final analysis either that the investigator did not determine both limits, or that the management tempts a man to do more than the average employer dares to ask directly.

52 The example of efficient coöperation between employer and employee in the power plants of public utility corporations here referred to demonstrated the value of the above principles for setting task and accomplishing the predetermined results in firing boilers. The diagram in Fig. 10, showing cost per kilowatt-hour of fuel relative to firemen's payroll and bonus before and after adoption of scientific basis for firing, presents, outside of the interesting reduction in cost since the change of method took place, another feature also of no less importance, namely, that since that time the unit cost remained practically constant, while previously it fluctuated considerably. Samples of daily power plant reports are shown in Figs. 11 and 12.

53 The writer does not claim to have made any new discovery or exhaustive treatment of the technique of the question. The undertaking of presenting to the profession a brief outline of systematic method of task setting for one particular job can be considered fairly fulfilled, if the necessity of thorough scientific research and accumulation of available data for further enlightenment of the many still obscure facts and their coördinations is sufficiently demonstrated.

APPENDIX NO. 1

54 The diagrams in Figs. 13 and 14 represent applications of the Grinevetski method of graphical analysis of the working process in a steam boiler. Briefly stated, the diagrams consist of two main curves: a heat curve TQ and a characteristic HQ, a third auxiliary curve, known as a radiation curve, being added for use in determining the influence of radiation of the incandescent fuel on the grate on the whole process. The heat curve is constructed from the temperatures of gases T as ordinates and the heat in the gases of corresponding temperature as abscissa Q. The heat developed during the combustion could be represented as a function of temperature. Assuming the following symbols:

B_h = Fuel consumed per hour in lb.
G_b = Weight of gases in lb. per 1 lb. of fuel burned
C_p = Average specific heat of gases (at p = const.)
T = Temperature of gases
T_b = Temperature of furnace
T_s = Temperature of escaping gases
T_a = Temperature of air entering the furnace
Q' = Heat in gases in B.t.u. at temperature T
Q_a = Heat in gases in B.t.u. at temperature T_a
Q = Heat of gases developed during combustion in B.t.u. per hour
Q_b = Heat value of fuel in B.t.u. per lb.

thus

$$Q = Q' - Q_a \quad \ldots\ldots [1]$$

and

$$Q' = cG_bB_ht \quad \ldots\ldots [2]$$

The specific heat of the gases could be represented as a lineal function of temperature

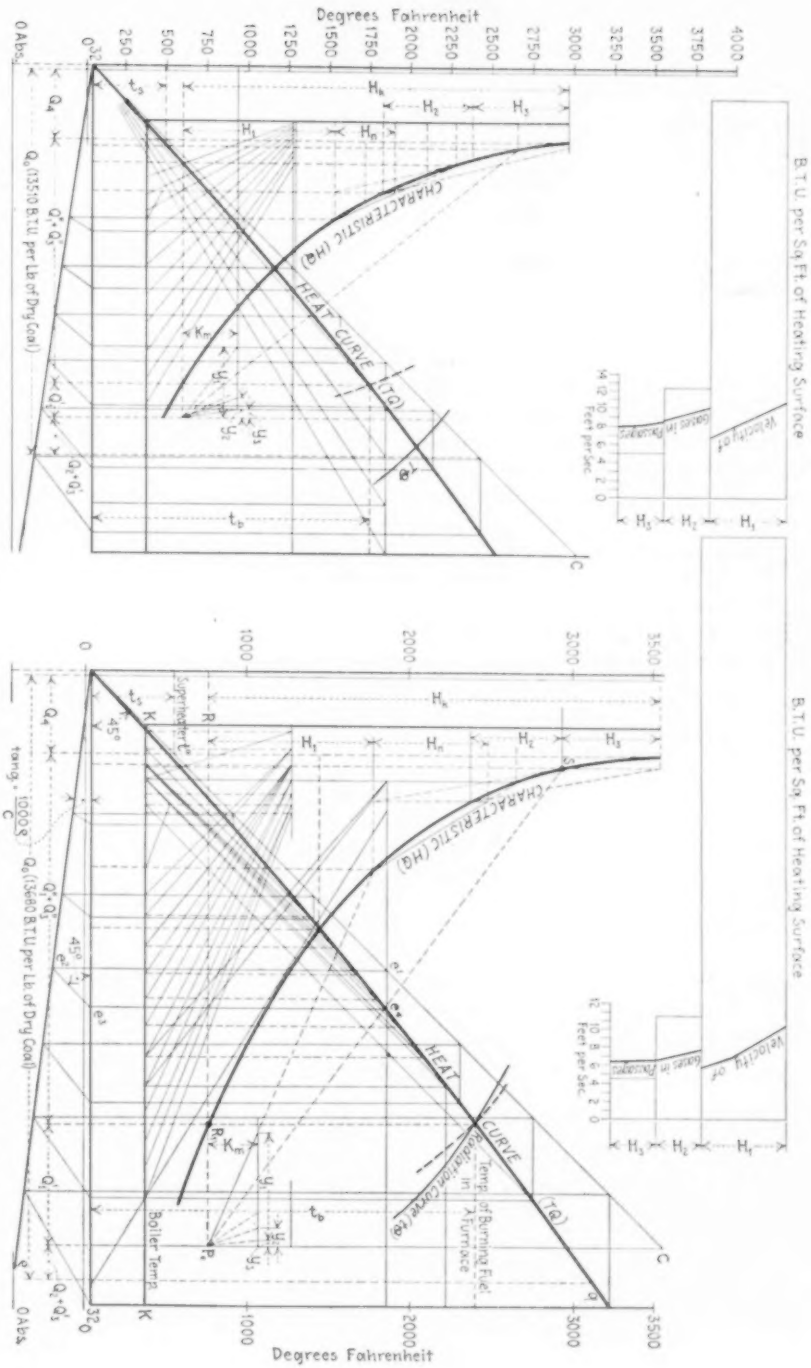
$$C_p = c + \delta t \quad \ldots\ldots [3]$$

where c and δ are constant for the fuel of given composition and definite percentage of CO_2 in gases. For variable CO_2 and different fuels, c and δ vary but slightly and for all practical use have little effect on the calculation.

55 Thus from equations [2] and [3] we have

$$Q' = cG_bB_h\left(t + \frac{\delta}{c}t^2\right) \quad \ldots\ldots [4]$$

In this cG_bB_h is constant, except in case of infiltration of air into gas passages, and at any given condition of combustion can be taken as a scale for the diagram. The expression $\left(t + \frac{\delta}{c}t^2\right)$ is an equation of a parabola, and as such can be easily plotted. Assuming C, in inches, is a scale for ordinate equal to 1 deg. fahr. and W, in inches, is a scale for abscissa equal to 1 B.t.u., equation [4] becomes:



FIGS. 13 AND 14 DIAGRAMS INDICATING METHOD OF ANALYSIS OF THE WORKING PROCESS IN STEAM BOILERS

$$Q'w = \left(t + \frac{\delta}{c} t^2\right) b \quad \ldots\ldots [5]$$

and the method of plotting this curve is evident. It gives the heat curve TQ. If $Q' = Q_a$; then $Q = 0$; and therefore the ordinate shall pass through temperature T_a of the curve.

56 From equations [4] and [5]

$$w = \frac{C}{cG_b B_h} \text{ in inches} \quad \ldots\ldots [6]$$

Referring the fuel consumption per hour to a unity when $B_h = 1$ lb., equation 6a is obtained

$$w_o = \frac{C}{cG_b} \text{ in inches} \quad \ldots\ldots [6a]$$

57 The application of this heat curve is apparent. The temperature of the gases T is known and, being represented in a scale b, if referred to the curve and projected on abscissa, gives the corresponding heat in the scale $w = 1$ B.t.u. Thus from the heat value of the fuel and the weight of the gases developed from its combustion, may be found the theoretical temperature in the furnace T'_b by projecting on the curve $Q_b w_o$ and reading the temperature at this level on the corresponding scale of ordinates.

58 The deviation of the parabola from the straight line OC indicates the variation of specific heat of gases with the change of temperature, which is considerable at the high temperatures. If

$Q_o = B_h Q_b$ = heat available

$Q_1 = Q'_1 + Q''_1$ = heat utilized $\begin{cases} Q'_1 \text{ by radiation} \\ Q''_1 \text{ by convection and transmission} \end{cases}$

Q_2 = the loss due to incomplete combustion

$Q_3 = Q'_3 + Q''_3$ = external losses $\begin{cases} Q'_3 \text{ in furnace} \\ Q''_3 \text{ in gas passages} \end{cases}$

Q_4 = is the heat lost in escaping gases.

We can study graphically the heat balance as well as ascertain and locate the cause of any loss due to inefficient performance of a certain part of the boiler or furnace. Q_4 is directly shown by the heat curve, and an evaporative test supplies the data of Q_1; hence the equation of heat balance is:

$$Q_2 + Q_3 = Q_o - (Q_1 + Q_4) \quad \ldots\ldots [7]$$

Similarly by further graphical analysis the other elements could be ascertained.

59 It is useful to plot also the curve of radiation $T\theta$ which represents the equation

$$\theta = \left\{\frac{T + 459.2}{491.2}\right\}^4$$

In accordance with the equation of Stephen for an ideal black body, the heat transmitted by radiation is:

$$Q = \sigma F T^4$$

where T = absolute temperature of the body, F = radiant area, σ = constant. This constant in metric units for lamp black $\sigma_1 = 4.33$ cal per m^2 per hr., or 1.678 B.t.u. per sq. ft. per hr. Professor Grinevetski gives a table (see Table 1) for θ at temperatures from 302 deg. fahr. to 2912 deg. fahr. The intersection of the radiation curve, plotted in accordance with this method, with the heat curve

TABLE 1 VALUES OF θ AT VARIOUS TEMPERATURES *

T, Deg. Cent.	θ	T, Deg. Cent.	θ
150	320	900	18,930
200	501	950	22,370
250	748	1000	26,540
300	1078	1050	30,650
350	1506	1100	35,550
400	2051	1150	41,000
450	2732	1200	47,080
500	3571	1250	53,800
550	4590	1300	61,210
600	5810	1350	69,370
650	7260	1400	78,340
700	8960	1450	88,150
750	10,955	1500	98,810
800	13,210	1550	110,460
850	15,980	1600	122,800

* Values calculated in c. g. s. units.

determines T_b, the temperature in the furnace and Q'_1, the heat utilized by radiation. In this case, like in all others, the comparison of ideal conditions with those observed gives a valuable indication as to what direction we must apply our efforts, and in most cases as well supplies us with the means of measurement. Only the analysis of the whole problem in its entirety, however, can tell whether further efforts are worth trying in practice or not.

60 The rule made manifest in this research on radiation could be expressed as follows: Under equal conditions of combustion, the temperature of the furnace is in direct proportion to the rate of firing

$$B_h = \frac{\text{lb. of fuel per hour}}{\text{area of grate surface}}$$

and in inverse proportion with the intensity of radiation.

61 The second main curve, or characteristic, has the same heat scale on abscissa as the heat curve, but as ordinates we take the area of heating surface, H. If

k = factor of heat transmission in B.t.u. per sq. ft. per hr., and

T_k = temperature of boiler water in accordance with Redtenbacher's researches, we have

$$k(t - t_k)dH = -dQ$$

whence

$$\frac{dQ}{dH} = k(t - t_k) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [8]$$

62 This equation can be plotted very conveniently, if k is constant, and the tangent of the angle ϕ, between tangent to characteristic curve and the line of ordinates, is in direct proportion to the difference of the temperature of the water in the boiler and the temperature of the gases in contact with a given section of the heating surface. Thus, with T_k and k known, the shape of the characteristic curve is determined by the temperature of gases (abscissa Q) and is independent of the ordinate. This is a particularly convenient peculiarity,

since the curve can be plotted from any initial temperature without changing its shape; a number of tangents plotted in accordance with equation [8] determines the curve. From this equation it is evident, that with the decrease of $(t-t_k)$, tang ϕ decreases and with $t=t_k$, tang $\phi=0$, and our ordinate KH of the heat curve for temperature tk will be the asymptote to the characteristic curve. If with $t=t_k$, $H=0$, and the abscissa of the characteristic curve will be on the ordinate T_b of the heat curve scale. The ordinate of the characteristic curve starts from the axis thus located, $R-R$, which determines the area of heating surface in contact with the hot gases, while the corresponding temperature of gases is represented by the distances between OQ and tQ. The scale for the heating surface area is determined as follows:

$$f=\frac{nk}{cG_bB_h} \text{ in inches} \quad \ldots\ldots [9]$$

63 From this we can estimate the temperature of the gases in any part of the gas passages. If $H=H_k$ (total heating surface), we know from the heat curve that $T=T_a$ and Q_4. On the other hand, if we know the various temperatures, we can locate the sections of gas passages in which they are present and from the characteristic, the areas of the heating surface. If k (factor of heat transmission) is unknown, but T_b and T_a are known, the factor of heat transmission itself can be determined from equation [8].

64 The rate of driving the heating surface is shown by the characteristic curve. Assume

$$g=\frac{dQ}{dH}$$

for average conditions and

$$g_m=\frac{Q'-Q''}{H''-H'}$$

for the local rate of driving in B.t.u. per sq. ft. per hr. Also

$$g_m=\frac{Q'-Q''}{H''-H'}$$

which equals average rate of driving for a given portion of a heating surface.

65 The first equation is a tangent of the angle between a line tangent to the characteristic curve and the axis of ordinates, and the second, a tangent of an angle between a line normal to the same ordinate and $(H''-H')$, or

$$\text{tang } \phi=\frac{dQw}{dHf} \quad \ldots\ldots [10]$$

Since

$$w=\frac{b}{cG_bB_h}$$

and

$$f=\frac{nK}{cG_bB_h} \quad \ldots\ldots [9]$$

the equation becomes

$$g=\text{tang } \phi \times \frac{nk}{b} \quad \ldots\ldots [11]$$

This can be plotted as

$$g=\frac{y}{h} \quad \ldots\ldots [12]$$

where from $h=\frac{b}{n}$ is a scale for the rate of driving the heating surface = 1 B.t.u. per sq. ft. per hr. From equation [12] can be determined g_m for the entire boiler and furnace in which case Q'_1 should be added as radiant heat absorbed.

66 In determining the volume of gases, the volume V with p = constant is proportionate to the absolute temperature and evidently can be read on the ordinates of the heat curve where the scale for volumes per second in cu. ft. will be

$$V\zeta=\frac{1670\,h_b b}{(g_b-1)B_h\zeta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [13]$$

where

h_b = barometric pressure

ζ = ratio of volumes of gas and air at the same temperature.

67 Thus, if h_b = 760 mm,

$$V\zeta=\frac{1{,}260{,}000\,b}{(g_b-1)B_h\zeta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [13a]$$

Whence from equations [13 and 13a], we learn the scale for volumes of gases per second, we can determine the volumes per second for any temperature at any portion of gas passages. Consequently taking into consideration the cross-sectional area of gas passage, we can determine the average velocity of gases in the corresponding places.

APPENDIX NO. 2

DIRECTIONS FOR USE OF POWER PLANT LOG CALCULATOR

Weight of Feedwater. Set 10B (inner scale) opposite the Wilcox water meter reading found on the dial. The result in pounds appears on the dial opposite the feed temperature marked on the disk.

Cubic Feet into Gallons. Set 10B opposite the number of cubic feet on the dial. The result in pounds appears on the dial opposite the observed temperature.

Steam Consumption per Kilowatt-Hour or Horsepower-Hour. Set the kilowatts or horsepowers of output on the disk opposite the number of pounds of steam consumed, read on the dial. The result in pounds per kilowatt or horsepower-hour appears on the dial opposite 10B of the disk.

Fuel per Unit of Output. Same method as above.

Actual Evaporation. Set the number of pounds of fuel, read on disk, opposite the number of pounds of water evaporated, on the dial. The result appears on the dial over 10B of the disk.

Factor of Evaporation. Find feedwater temperature at the left of the diagram in the center of the chart and follow the horizontal line to its intersection with the diagonal line representing gage pressure; then follow the vertical line down and read the factor of evaporation at the bottom.

Equivalent Evaporation. Set 10B of the disk opposite the factor of evaporation number on the dial. The result appears on the dial opposite the actual evaporation number on the disk.

Efficiency of Boiler and Grate. Set the heat-value factor (B.t.u. per pound of fuel) shown on the disk opposite 10A on the dial. The result appears on the dial opposite the equivalent evaporation number on the disk.

Cost of 1000 Lb. of Equivalent Steam. Set the observed efficiency number on the disk opposite the cost of 1,000,000 B.t.u. in the shape of fuel shown on the outer scale of the dial (which is designated for calculation of cost, but does not show the cost). The result appears in cents on the dial opposite 10B.

Load Factor. Set the number of kilowatts in the peak power load on the disk opposite the number of average power read on the dial. The result appears on the dial opposite 10B.

Thermal Efficiency of the Whole Plant. Set 10B of the disk opposite the constant for kilowatts or horsepower printed on dial. Note the point on the dial opposite the output number on the disk. Set the disk's figure of pounds of fuel consumed under previously located point on dial opposite 10B. Set again the disk so that opposite the point thus found will be the number of B.t.u. per pound of fuel used. Do not use constants for the determination of boiler efficiency. The result appears on the dial opposite the 10B mark.

Use as Slide Rule. Any multiplication can be made by following the rule for determination of equivalent evaporation, and division by following the rule for load factor. All these calculations and others not mentioned can be made quickly and accurately with the calculator.

APPENDIX NO. 3

DIMENSIONS AND PROPORTIONS OF WATER TUBE BOILERS, WARRIOR RIDGE, PA.

Rated horsepower	600
TUBES	
15 rows, 20 tubes each, total	300
Diameter, in	4
Circumference, in	12.566
Length, ft	18
Area of one tube, sq. in	2,714.25
Total tube area, sq. in	814,276.8
sq. ft	5,634.7
LEGS	
13 ft. x 8.5 ft. x 2 ft	221.0
Tube holes (2 x 300 x 12.566), sq. ft	59.4
Actual heating surface of legs (221.0 − 59.4), sq. ft	161.4
Lower part of drums, sq. ft	180.4
Effective water heating surface, sq. ft	59,967
SHAKING GRATES	
Width of grate, ft.–in	13–1
Depth of grate, ft.–in	7–6
Area of grate, sq. ft	100
Number of air slots in sections	21
Size of slots, in	5 x 1.75
Air space in each section	
Slots, sq. ft	0.260
Around section, sq. ft	0.90
Total, sq. ft	0.350
Proportion of water heating surface to grate area	58.2:1
Air space to grate area, per cent	35
Proportion of flue area to grate area	0.23:1
Ratio of grate surface to flue area	4.35:1
Area of 4 ash pit doors, sq. ft	40.42
Area of uptake, sq. ft	23
Dead space in tubes, per cent	42
BRICK LINED CHIMNEY (common for 4 boilers)	
Height from base, ft	207
Height from grate, ft	200
Smallest diameter top, ft	10
Smallest area, sq. ft	28.5

TABLE 2 DATA AND RESULTS OF EVAPORATIVE TRIALS

ON BATTERY OF 2 WATER TUBE, EDGE MOORE BOILERS, HAND FIRED, AT WARRIOR RIDGE PLANT OF THE PENN CENTRAL LIGHT AND POWER COMPANY.

		Test No. 1 Average for 80 Days	Test No. 2 13 Hours	Test No. 5 14 Hours	Test No. 3 12 Hours	Test No. 6 10 Hours	Test No. 10A 6 Hours	Test No. 10B 8 Hours	Test No. 8 10 Hours
	AVERAGE PRESSURES								
11	Steam pressure by gage, lb. per sq. in.	173.7	173.3	162.0	163.3	165.0	168.0	165.0	160.0
12	Force of draft between damper and boiler, in. water	0.85	0.70	0.55	0.58	0.50	0.64	0.62	0.71
13	Force of draft in furnace, in. water	0.45	0.34	0.32	0.35	0.30	0.26	0.5	0.35
14	Force of draft in ash-pit, in. water	0.09	0.18	0.07	0.11	0.08	0.05	0.04	0.08
14a	Velocity of air through ash-pit doors, ft. per min.	*	*	588.0	*	533.0	637.0	550.0	655.0
	AVERAGE TEMPERATURES								
15	External air, deg. fahr.	37.8	47.4	32.0	46.2	42.0	43.0	33.0	28.0
16	Fire room, deg. fahr.	54.0	62.6	53.5	63.2	61.0	45.0	45.0	44.0
17	Steam, deg. fahr.	479.6	486.0	508.0	477.0	514.3	535.0	532.0	497.5
18	Feedwater entering heater, deg. fahr.	68.0	71.0	57.0	66.0	62.0	....	....	....
20	Feedwater entering boiler, deg. fahr.	167.5	168.0	153.7	154.3	166.5	123.6	122.5	141.6
21	Escaping gases from boiler, deg. fahr.	575.0	495.0	590.0	535.0	570.0	650.0	660.0	....
	FUEL								
23	Size and condition	R of M Broad Top	R of M Broad Top	R of M, Bitum. Broad Top	R of M Broad Top	R of M, very wet Broad Top	R of M, clean, from Broad Top East	Mixed, weathered, Broad Top and Moshan	R of M, semi-Bitum., Clearfield
25	Weight of coal as fired, lb.	27793.0	38339.0	54330.0	36379.0	35850.0	25250.0	29750.0	44750.0
26	Moisture in load, per cent	1.5	2.0	2.3	1.6	3.1	2.9	2.2	4.4
27	Total weight of dry coal consumed, lb.	27382.3	37572.2	53080.0	35797.0	34739.0	24720.0	29095.0	42780.0
28	Total ash and refuse, lb.	3850.0	5640.0	6475.0	4589.0	5385.0	2521.0	4226.0	5134.0
29	Quality of ash and refuse	white ash	loose	gray	clinkers	....	loose clinkers	fused clinkers	fused clinkers
30	Total of combustible consumed, lb.	23532.3	31.932.0	46605.0	31108.0	29454.0	22200.0	24869.0	37646.0
31	Ash and refuse to dry coal, per cent	14.5	15.0	12.2	13.1	15.5	10.2	15.2	12.0

* No Anemometer available

	APPROXIMATE ANALYSIS OF COAL									
32	Fixed carbon, per cent	75.1	74.4	78.0	77.1	75.9	77.0	71.6	69.6	70.7
33	Volatile matter, per cent	12.2	12.3	12.1	12.4	12.2	14.2	16.5	14.5	19.1
35	Ash, per cent	12.7	13.3	9.9	10.5	11.9	8.8	11.9	15.9	10.2
	Total on dry basis	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
34	Moisture, per cent	1.5	1.5	2.2	1.6	1.9	1.5	1.2	1.5	4.3
36	Sulphur separately determined	....	....	....	....	....	....	....	....	....
	CALORIFIC VALUE OF FUEL									
50	Calorific value of oxygen calorimeter per lb. dry B.t.u.	13786	13510	14233	13800	13680	14395	13594		14221
51	Calorific value per lb. of combustible B.t.u.	15791	15590	15640	15420	15527	15874	15770		15836
	ANALYSIS OF ASH AND REFUSE						Analyses Ash Clinker			Analyses Ash Clinker
44	Carbon (computed), per cent	27.2	43.0	17.7	20.2	21.0	21.8 6.2	....		23.7 5.1
45	Earthy matter (computed), per cent	72.8	57.0	82.3	79.8	79.0	78.2 93.8	....		76.3 94.9
	FUEL PER HOUR FOR BOILER									
46	Dry coal consumed per hour, lb.	1956.0	1445.1	1900.0	1493.05	1737.0	2060.0	1818.5		2139.0
47	Combustible consumed per hour, lb	1707.5	1249.0	1664.0	1296.0	1472.0	1800.0	1575.0		1921.0
48	Dry coal consumed per sq. ft. of grate surface per hr.	19.56	14.45	19.0	14.93	17.37	20.6	18.2		21.39
49	Combustible per sq. ft. water heating surface	0.29	0.21	0.28	0.223	0.25	0.31	0.27		0.33
49a	Wet coal per kw-hr., lb.	2.87	2.65	2.47	2.25	2.27	2.012	2.106		2.10
49b	Air per lb. of combustible, lb.	....	....	17.1	....	17.5	17.1	16.9		16.6
	QUALITY OF STEAM									
55	Superheat, deg. fahr.	102.9	109.7	136.1	104.8	141.3	160.5	159.0		126.5
56	Quality of steam (C. E. E.)	1.043	1.047	....	1.044	....	1.069	1.069		1.056
56a	Quality of steam (G. H. Barrus)	....	....	1.076	1.059	1.079	1.0906	1.090		1.071
	WATER									
57	Total weight of water fed to boilers, lb.	171,552	293,537	440,587	309,472	291,783	213,733	234,061		341,684
58	Equivalent water fed from and at 212 deg. fahr., lb.	198,303	339,329	523,461	361,340	343,808	262,977	291,755		406,672
59	Water actually evaporated, corrected for quality of steam, lb.	178,929	307,333	469,667	327,730	314,834	233,097	255,126		365,943
60	Factor evaporation	1.156	1.156	1.1881	1.1676	1.1783	1.2304	1.2294		1.1902
61	Equivalent water evaporated into dry steam from and at 212 deg. fahr., lb.	206,830	355,277	563,244	382,659	370,969	285,803	318,013		435,546

TABLE 2—*Continued*

		Test No. 1 Average for 80 Days	Test No. 2 13 Hours	Test No. 5 14 Hours	Test No. 3 12 Hours	Test No. 6 10 Hours	Test No. 10A 6 Hours	Test No. 10B 8 Hours	Test No. 8 10 Hours
	WATER PER HOUR–BOILER								
62	Water evaporated corrected for quality, lb.	12,780	11,821	16,774	13,655	15,741	19,425	15,945	18,297
63	Equivalent evaporation, lb.	14,774	13,665	20,116	15,710	18,548	23,817	19,876	21,777
64	Equivalent evaporation per sq. ft. of water heating surface, lb.	2.54	2.34	3.45	2.701	3.19	4.09	3.41	3.74
64a	B.t.u. absorbed per sq. ft. water heating surface	3161.5	2912.6	3357.6	3393.8	3096.8	....	....	3629.0
	HORSEPOWER								
65	Horsepower developed	428.2	396.07	583.1	455.3	537.6	693.3	547.1	631.2
66	Builders rated, h.p.	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0
67	Percentage of builders' h.p. developed	71.4	66.5	97.02	75.9	89.6	115.5	91.2	105.2
	ECONOMIC RESULTS								
68	Water apparently evaporated per lb. coal as fired, lb.	6.17	7.65	8.109	8.507	8.139	8.47	7.867	7.635
69	Equivalent evaporation per lb. of coal as fired, lb.	7.44	9.26	10.367	10.52	10.349	11.319	10.689	9.733
70	Equivalent evaporation per lb. of dry coal, lb.	7.55	9.46	10.611	10.66	10.678	11.521	10.930	10.181
71	Equivalent evaporation per lb. of combustible, lb.	8.79	11.12	12.085	12.301	12.594	12.874	12.78	11.569
	EFFICIENCY								
72	Efficiency of boiler, per cent.	54.02	69.21	74.98	77.412	78.78	78.70	78.64	70.261
73	Efficiency of boiler and grate, per cent.	52.37	67.94	72.35	75.00	76.03	77.667	78.023	69.479
73a	Efficiency of gasification of fuel in furnace, per cent.	98.51	99.8	96.5	96.9	96.5	98.6	99.02	98.8
	COST OF EVAPORATION								
74	Cost of coal per ton of 2240 lb. delivered to coal pockets.	$2.15	2.15	1.85	1.85	1.85	1.85	1.895	1.94
74a	Cost of coal per lb. delivered to coal pockets	$0.00096	0.00096	0.000826	0.000826	0.000826	0.000826	0.000826	0.000866
74b	Cost of 1,000,000 B.t.u. in shape of coal	$0.07	0.071	....	....	....	0.057	0.0622	0.0609
75	Cost of evaporating 1000 lb. of water under observed conditions	$0.155	0.125	0.1018	0.0968	0.1014	0.0975	0.105	0.1134
76	Cost of fuel for evaporating 1000 lb. of water from and at 212 deg fahr. (corrected for quality of steam)	$0.1291	0.1036	0.0796	0.0785 0.0741	0.0798	0.0729 0.065	0.0772 0.0719	0.0889 0.0831

	SMOKE OBSERVATIONS AND FIRING								
77	Smoke as observed, per cent	30	15	1	0	1	0	not observed	5
80	Kind of firing	Coking	Spreading	Spreading	Spreading	Spreading	Spreading	Spreading	Spreading
81	Average thickness of fire, in.	16	12	10	6	7	8	7	8
82	Average intervals between firings for each boiler, min.	22	15	15	8	7	8	10	10
83	Average time between times of leveling or breaking up, min.	....	....	....	....	....	60	60	45
	ANALYSIS OF DRY GASES								
84	Carbon dioxide, Co_2, percentage by volume	4.3	6.9	11.77	Orsat apparatus out of order, one reading CO_2 12.5 per cent	11.26	12.1	12.2	9.5
85	Oxygen, O, percentage by volume	13.0	13.1	8 11		7.56	7.7	6.2	10.2
86	Carbon monoxide, CO, percentage by volume	0.6	0.3	0.01		0.11	0.1	0.2	0.1
88	Nitrogen, N, percentage by volume	79.0	79.0	80.11		....	80.1	81.4	80.2
89	Hydrocarbons, HC, percentage by volume	4.1	0.7	1.11		2.07	1.1	2.4	1.2

Remark: Heating surface (water) as accepted in these computations does not include surface of steam drums and superheater tubes.

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The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

With this number the second year of the Foreign Review is concluded.

THIS MONTH'S ARTICLES

Now that purchase of coal by heat unit is gaining in popularity, the article by Dosch on taking coal samples for calorimetric tests and exact heat value determination is particularly timely, in that it recommends to supplement the usual calorimetric determination by a determination of non-combustible constituents of the coal, and, in the case of boiler tests, also by a test of ash. In the section of Hydraulics the exposition of the theory of Allievi on the phenomena of water-hammer is continued. A graphical method for the consideration of conduit characteristics is given, and the interesting fact is established that entirely dissimilar conduits may be represented by the same pair of characteristic parameters. The distinction between constructional and functional characteristics of a conduit is established, and it is shown that a change in one of the functional characteristics produces, with respect to water-hammer phenomena, practically a new conduit. The second part of the work of Allievi will be reported as soon as the publication of the text used as the original is concluded.

The article of Dumanois on Diesel Engines as applied for the propulsion of battleships brings out some of the difficulties with which the designer of the large Diesel engine has to contend, viz., excessive transient pressures and excessive temperatures in the cylinder, the latter, unless special precautions are taken, is apt to reach so high a limit as to cause the decomposition of the lubricant and consequent disturbances in the operation of the engine. The author also calls attention to the difficulties due to the rise, in large engines, of excessive stresses. In the same section is described an interesting modification of the Oechelhauser oil engine, with its highly efficient system of scavenging and economical use of compressed air. Attention is called to the German regulations on the use of liquid fuel locomotives underground, the strict enforcement of which would certainly help to prevent accidents due, e. g., to

careless use of an inflammable fuel under conditions where fire and explosions are particularly dangerous.

Two constructions are described with aerial screw propulsion on land and water, which may be of particular interest in the North where an efficient system of mechanical propulsion over snow is desirable. The next abstract, on mechanical models and methods of demonstrating mechanical law, may be of interest to teachers of mechanics. In the same section A. Lechner shows how certain problems of torsion may be solved graphically, and, in particular, how the distribution of shear-stresses in a cross-section may be determined.

Several interesting new constructions are described in the section Steam Engineering, such as the R. Wolf superheated steam compound locomobile, the Ferranti pressure-regulating valve, the new 2C type fast train superheated steam four-cylinder Prussian locomotive, etc. There will also be found data on power consumption in air liquefaction, dynamic stresses in steam turbine blading, discussion on the importance of notch shock tests, graphical differentiation, etc.

ABSTRACTS OF ARTICLES

Alloys

AUTOGENOUS WELDING OF COPPER AND COPPER ALLOYS (*Autogene Schweissung von Kupfer und Kupferlegierungen. Acetylen*, vol. 16, no. 18, second section, p. 173, serial article. *p*). Contains a detailed list of copper alloys, giving trade names and chemical composition of various bronzes, brasses, bearing metals, bell metals, etc.

Fuels

INFLUENCE OF NON-COMBUSTIBLE MATTER IN COAL ON TAKING SAMPLES AND EXACTNESS OF HEAT VALUE DETERMINATIONS (*Einfluss des Unverbrennlichen der Kohle auf die Probeentnahme und die Genauigkeit der Heizwertbestimmung*, A. Dosch. *Braunkohle*, vol. 12, no. 31, p. 531, October 31, 1913. 5 pp., 2 tables. *ep*). The author expresses a doubt as to whether a sample used for calorimetric tests really gives a fair knowledge of the heat value of the large masses of the coal used, e. g. in evaporation tests of a boiler. To determine this he recommends an additional determination of the percentage of noncombustible matter in the coal sample, and also in the ash after the test, such recommendation being based on the supposition that the more uniform the constitution of the coal, the more the calorimetric test data approach the actual heat value. This method would have been very simple, if, on the one hand, the residues of combustion consisted of incombustible matter exclusively, and if, on the other hand, none of this matter were carried out of the smoke-stack by the draft. The amount of combustible matter present in the residues of combustion can be determined without much trouble and with fair exactness by direct analysis, while the amount of noncombustible matter carried up the flue can be in most cases only estimated. The author presents a tentative arithmetical method for calculating the actual heat value of a fuel from the calorimetric data and amount and constitution of ash in the calorimeter and on the grate.

Hydraulics

THEORY OF THE WATER HAMMER (*Théorie du coup de bélier*, L. Allié-vi. *Bulletin technique de la Suisse Romande*, vol. 39, nos. 11, 14, 15, pp. 121, 159, 171, June 10, July 25, August 10, 1913. Serial article, not finished. *tA*). Continuation of the abstracts published in *The Journal*, August 1913, p. 1287, September 1913, p. 1434, and November 1913, p. 1685. The systems of values characterizing the conduit may be represented graphically by means of a linear abacus. Since $\rho = \frac{av_o}{2gy_o}$, it may be represented as a function of v_o, in a system of rectangular coördinates (Fig. 1A) by a straight line passing through the origin; the angular coefficient of this line will depend on the magnitudes of y_o and a, or, in the final count, on the load y_o, so that the complete system of ρ, for all

possible conduits, i. e. for all y_o possible, and for all normal velocities v_o permissible, will be represented by a bundle of rays (Fig. 1A) starting from the origin of the axes ρ and v_o. If, however, the thickness of the walls of the conduit is determined, as is usually the case, by the magnitude of the static load y_o, the velocity of propagation of variations a is a function of y_o, so that the entire system of conduits represented by the two parameters ρ and ϑ is reduced to only a double infinity. It is important to understand very clearly that under this triple (or double as the case may be) infinity of conduits, characterized by the two elements ρ and ϑ, are really grouped conduits quite different from one an-

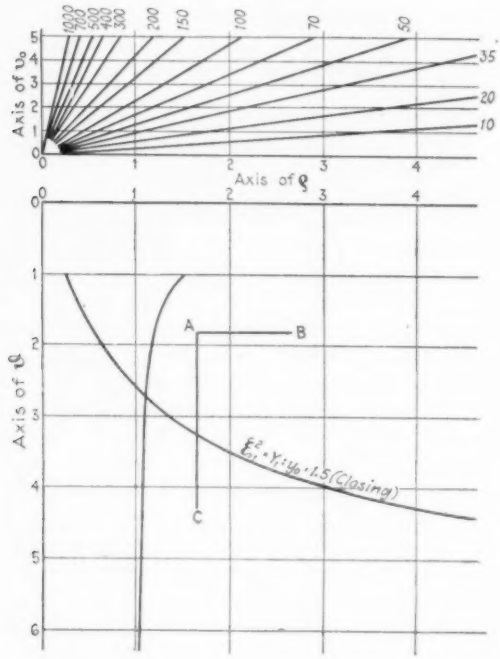

FIG. 1 ABACUS FOR CALCULATING, AND CARTESIAN SYNOPSIS OF, WATER HAMMER PHENOMENA IN DIFFERENT CONDUITS

other, though always within the limits of technical application. Thus the two conduits characterized by the following elements:

(1) $y_o = 300$ m.; $a = 1000$ m./sec.; $L = 900$ m.; $v_o = 3.60$ m./sec.; $\tau = 9$ m./sec.

(2) $y_o = 100$ m.; $a = 840$ m./sec.; $L = 300$ m.; $v_o = 1.43$ m./sec.; $\tau = 3.6$ m./sec.

though entirely dissimilar are represented by the same pair of parameters

$$\rho = 0.60 \quad \text{and} \quad \vartheta = 5.$$

Out of the five elements characterizing a conduit under normal operating conditions, three are constructive and usually invariable: y_o, a and L, while the other two are functional, v_o and τ, their magnitude undergoing frequent and important modifications, as e. g., in closing or opening the closing gate, or otherwise varying the flow in the conduit. It is therefore important clearly to realize

that, when one of these functional elements is changed, the conduit, in as far as the occurrence of water hammer is concerned, *becomes practically a new conduit*, in which the laws governing these phenomena may produce actions entirely different from those produced with the original values of the variable elements v_0 and τ.

It appears thus that, by giving to the parameters ρ and ϑ all the values which they can have in practical applications, one may determine the double infinity of conduits which embraces all the imaginable conduits as well as all the operations of the closing gate; but each of these conduits, determined by one pair of the parameters ϑ and ρ, represents in reality a triple (or double) infinity of conduits in which the water hammer rises to the same relative values and follows the same laws. And it is this particular grouping of all the imaginable conduits which makes possible a systematic and complete study of the water hammer and full understanding of the theory of those phenomena. From these considerations is naturally derived the idea of *cartesian synopsis*, which, in the case of conduits, is obtained by representing graphically, on a system of rectangular coördinates ρ and ϑ (Fig. 1B) all the laws governing the phenomena of water hammer, i. e. the deductions which may be derived from the fundamental system of equations (more about this graphical system of representation will be said later).

Since the characteristic ρ varies between 0.10 and 10, the ratio W_0:W, kinetic energy to potential energy, varies between 0.04 and 400, or in the ratio of 1:10,000, which explains why the phenomena of water hammer, functions of the relative values of these two quantities of energy, are apt to attain relatively widely varying values and to follow quite different laws, in accordance as one has to deal with low or high heads, as will be proved later.

Internal Combustion Engineering

Application of Diesel Engines to War Vessels (*Application des moteurs Diesel aux navires de guerre*, P. Dumanois. *La Technique moderne*, vol. 7, no. 8, p. 257, October 15, 1913. 3 pp., 1 fig. *mA*). In a previous article (*The Journal*, June 1913, p. 1052) the author showed that there occur in large Diesel engines far higher pressures than was usually supposed. In this article he discusses the problem of heat elimination from the cylinder of the large Diesel engine, and shows that here again are little understood difficulties in the way of building large units.

Influence of the thickness of walls of the combustion chamber. Let θ be the temperature of the gas in the cylinder; T_1 temperature of the wall inside the combustion chamber; T_2 temperature of the wall outside the combustion chamber; T_3 temperature of the cooling water; s area of the surface of the inner walls of the combustion chamber; S area of the surface in contact with the cooling water; ϵ thickness of the wall; K coefficient of heat emission of the gas (heat emitted per hour per meter square); K' coefficient of transmission of heat between the external wall and the cooling water (heat transmitted per hour per meter square); C coefficient of conductibility of the metal of the wall; θ, T_1, T_2, s are functions of the angle of crank ϕ.

In accordance with the theories of Nadal and Kirsch on the influence of walls in steam engines, fully applicable in this case, the average temperature T inside the wall may be represented by the formula:

$$T = A_0 - Bx + A_1 e^{-mx} \cos(\varphi - a_1 - mx)$$

where x is the thickness from the inner wall out; A, B, A_1, m and a_1 are constants.

At each point of the wall, the temperature oscillates in the neighborhood of the value corresponding to the straight line $T=A_0+Bx$.

On the other hand the amplitude of oscillations decreases very rapidly on account of the presence of the member e^{-mx}, and can be considered as zero from a certain value of x up, this value being only a few millimeters. In this way, the mass of the cylinder walls acts as a sort of thermal flywheel, and T_2 is practically constant all along the external wall. Therefore, under permanent conditions of operation, the quantity of heat A taken up per hour by the cooling water is equal to

$$Q=\frac{K}{\Phi}\int_0^{\Phi} s(\theta-T_1)d\varphi=\frac{C}{\epsilon}S(T'_1-T_2)=SK'(T_2-T_3)$$

where φ is the angle described by the crank in an hour, and $T'_1=\frac{1}{\Phi}\int_0^{\Phi} T_1 d\varphi$.

From this expression the author derives the following equation:

$$\frac{\frac{1}{\Phi}\int_0^{\Phi} s(\theta-T_1)d\varphi}{S(T'_1-T_2)}=\frac{CK'}{K(C+K'\epsilon)}$$

But T_2, the temperature of the cooling water does not vary much, and therefore T'_1 and T_1, both of which vary in the same sense, increase when ϵ increases, which means that the temperature of the inner wall approaches that of the gas when the thickness of the wall increases. There is therefore a certain limiting value to the power that may be derived from a single cylinder, this limit being reached when the temperature of the inner wall rises high enough to cause a decomposition of the lubricating oil with its attendant troubles. The theoretical determination of this limit is scarcely possible at the present time, especially as the value of K on which it depends to a considerable extent is not exactly known But the data from tests made with a 400-h.p. two-stroke cycle Koerting engine have shown that at certain points the temperature of the walls is in the neighborhood of 200 deg. cent. (392 deg. fahr.).

The author shows further that, in a large engine, the usual arrangement of piston directly connected with the crosshead-pin is unsuitable because it forces the piston and cylinder to support the reactions normal to the walls of the latter and due to the obliquity of the connecting rod. The only duty that may therefore be imposed on the piston is that of securing a close packing for the volume varying at each instant, and of transmitting the normal reactions to a special mechanical organ, which is nothing else than the crosshead beam and slide-bar of the steam engine, the use of which, while securing a higher safety of operation, rather complicates the design of the engine.

The cooling of the piston. As regards the action of heat on the different parts of the combustion chamber one finds that during the entire periods of expansion and exhaust, the inner wall of the piston head and of the cylinder head are in contact with the hot gases, while the different parts of the cylinder walls are in contact with them only for a fraction of the time, and therefore the piston head and cylinder head have a tendency to acquire a higher average temperature than the walls of the cylinder. In addition, in the Diesel engine there is a calorific

lack of symmetry due to the method of injecting the fuel. The piston head receives during the entire period of injection the shock of the hot gases, and, if the average temperature of combustion does not exceed 1550 deg. cent. (2822 deg. fahr.), one may reasonably assume that the temperature of the gas jets burning under considerable pressure under conditions similar to that of a welding burner, must be substantially above the average. This flame acts probably in two ways, first, tending to break up the surface of the piston head by its kinetic energy, and then modifying the physical structure and chemical constitution of the surface layers of metal by its high temperature and carburizing action. These actions are only to a limited extent minimized by the use of diffusors spreading the jet over a wider area. In slow running engines with low power output the cooling of the cylinder and piston head does not present any serious difficulties, but in the case of large engines running at high speeds water cooling of the piston has to be used, and this involves mechanical complications and danger of water leaks into the crank case; further, in some cases, where a mixture of sea water with the lubricant appeared to be objectionable, cooling of the piston by oil circulation had to be adopted. The importance of the above considerations becomes clear when one remembers that for driving battleships, engines will have to be used with an output of at least 1000 h.p. per cylinder.

The Oil Engine of the German General Electric Company (*Die AEG-Oel-maschine. Oel-und Gasmaschine*, vol. 13, no. 7, p. 97, October 1913. 3 pp., 7 figs. *d*). The purpose of the described engine was to provide an economical and easily handled prime mover for outputs under 500 h.p. for which the steam turbine is not economically efficient. The engine is built in four types, two, three and four cylinders, 125 h.p. per cylinder. It is of the two-stroke cycle Diesel type, approaching in its construction the so-called Oechelhauser design. There are in each cylinder two pistons which at one dead point are at minimum, and at another dead point at maximum distance from one another. One of these pistons covers and uncovers the passage for the escape of the products of combustion from the working cylinder, the other piston similarly operates the slots admitting the air for the next cycle. The heavy and unwieldy valves for the admission of air and exhaust of gases are therefore eliminated, and there remain only two valves, one for the admission of fuel, and the other for compressed air for starting. At the same time, since the slots may be made all around the cylinder, there is plenty of room for making them large enough for the most economical working of the engine. The combustion occurs with the pistons at the closest distance; the pistons are driven apart, and first the exhaust slots are opened by the upper piston, and then the air admission slots by the lower one; this fresh air acts somewhat like a piston, and thereby helps to drive the gases of combustion out in the most economical manner. The thorough and still economical manner of scavenging is the reason why the described engine, notwithstanding extremely generous dimensions of all bearings and journals, is as economical with respect to fuel consumption as the slower running four-stroke cycle engine. Owing to the very short time available for the admission of fresh air into the cylinder, and the low pressure used, a scavenging pump must be employed. It is connected with the working cylinder by placing its cylinder with its piston under the working piston, but in the AEG-oil engine the fresh air pump *C* (Fig. 2) is driven by a separate crank placed at the end of the crankshaft opposite the dynamo side. Immediately above the scavenging pump is

located the two-stage air compressor *D–E* for the compressed air for injecting the fuel. The scavenging pump compresses the air to a comparatively low pressure. The modern development of the oil engine is preferably in the direction of the two-stroke cycle type, where complete replacement of the gases of combustion by fresh air and economical use of compressed air are the fundamental conditions of economical operation, while the pressure of the air used for scavenging must also be selected with due regard to economy.

Regulations for the Use of Liquid Fuel Locomotives Underground (*Bedingungen für den Lokomotivbetrieb mit flüssigen Brennstoffen unter Tage. Braunkohle*, vol. 12, no. 28, p. 486, October 10, 1913. 2 pp. *g*). Regulations for the use of locomotives using liquid fuel underground published by the Halle Royal Mining District Administration. The regulations order, among other

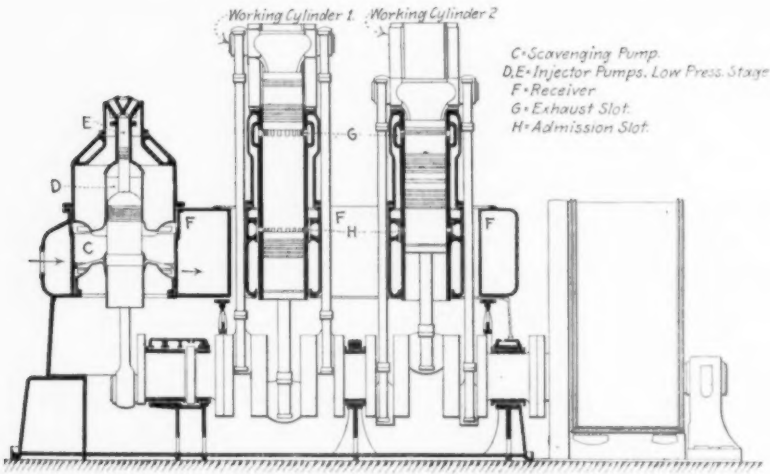

Fig. 2 Oil Engine of the German General Electric Company

things, that the locomotives may be filled with fuel only in special rooms, where facilities are provided for effectively preventing all spilling of the fuel on the locomotive or into the room; that no fuel may be used for other purposes, such as cleaning, and that in case of fire, all the openings in the room must be immediately and completely closed. Special provisions are made for the safety of the room where the locomotive is filled with fuel, such as the use of fireproof doors which may safely be closed from outside, use of electric light or safety lamps, and signs prohibiting the entrance of persons not employed on the premises. Locomotives left without attendance must have their starting crank removed, or otherwise made safe against being started accidentally. The construction of locomotives is prescribed so as to exclude the possibility of fire emission either through the air suction, or gas exhaust pipes. The locomotive engineer must be at least 21 years old.

Direct Reversal of Internal-Combustion Engines (*Die unmittelbare Umsteurung der Verbrennungskraftmaschinen*, Pöhlmann. *Verhandlungen des*

Vereines zur Beförderung des Gewerbefleisses, no. 7, September 1913. p. 309, 84 pp., 97 figs. *d*. Article not finished). Discussion of various systems for the reversal of internal-combustion engines of various kinds. The author attempts to prove that, as far as reversibility is concerned, the internal-combustion engine is at least as good, in some respects even better than the steam engine, and that while the reversing in construction is somewhat complicated, it is simple and reliable in operation.

Lubrication

SOME EXPERIMENTS ON COMBINED OIL AND GRAPHITE LUBRICATION (*Alcuni esperimenti sulla lubrificazione combinata con olio e grafite*, A. Mosser. *L'Industria*, vol. 27, no. 41, p. 658, October 12, 1913. 2 pp., 7 figs. *e*). The author made some tests on friction in lubricated parts, using both pure oil and oil mixed with oildag (1.7 and 4 per cent of the latter), and found that the presence of oildag unfavorably affected both the rise in temperature and friction. Two series of tests were made: one at constant temperature, with a Thurston testing machine, and another at variable temperature, the diagrams in the latter case being taken automatically by an Ossag-Wendt machine.

Mechanics

HYDROPLANES AND HIGH-SPEED CARS WITH AERIAL PROPELLER DRIVE (*Gleitboote und Schnellwagen mit Luftschraubenantrieb*, Bejeuhr. *Dingler's polytechnischers Journal*, vol. 328, no. 44, p. 698, November 1, 1913. 1 p., 2 figs. *d*). The aerial propeller becomes of steadily growing importance as a means of propelling vehicles along the surface of the earth and water. In France Tellier built for a private sportsman a hydroplane with an aerial propeller drive which on trials developed a speed of 70 km. (43 miles) per hour. The boat has three floats, of the hydroaeroplane type, with one float in front of the other two, all the floats being connected with the boat hull by steel tubes. A 50-h.p. Daimler-Mercedes water cooled engine, placed rather low, transmits its power through a chain drive to a Levavasseur propeller high above it, having a diameter of 2.8 m. (9 ft. 2 in.). The fuel is delivered to the engine under pressure. The high speed of the boat was probably due partly to the fact that, at full speed, the floats were immersed in the water not more than 3.5 in. (9 cm.).

Another application of the aerial propeller was developed to answer concrete practical requirements. The French government maintains an aeronautical station at Biskra, Northern Sahara, where tests are constantly carried on on the behavior of flying machines of various types under the exacting conditions of tropical temperature and desert sand. Considerable trouble has been experienced by rescue parties for aeroplanes stalled in the desert, as automobiles of the usual types are unable to travel along the shifting Sahara sands. To remedy this condition, Lieutenant Lafargue and Engineer Cros have developed a light car driven by a four-blade aerial propeller, and traveling on 12 light pneumatic tire wheels set in pairs. The propeller is driven by a 50-h.p. Gnome engine. During the tests of the car made at Biskra it handled without trouble stiff sand hills at the rate of 25 km. (15.5 miles) an hour, and traveled along shifting sand without any trouble from the sinking of wheels.

CONCERNING NEW MECHANICAL MODELS AND DEMONSTRATION EXPERIMENTS (*Über neue mechanische Modelle und Vorführungsversuche*, A. Lechner. *Zeits. des*

Vereines deutscher Ingenieure, vol. 57, no. 42, p. 1674, October 18, 1913. 2 pp., 8 figs. *d*). Description of several models for use in lectures and school teaching, for the demonstration of mechanical theorems. The models described comprise demonstrations for showing precession motions or a rotating disc, and permit of making quantitative determinations of this phenomenon in accordance with the Poggendorf theory of gyration; another model exhibits the advance in the spring point and motion of the polar star from east to west; a third shows the influence of the moment of deflection on the operation of an engine. Other models demonstrate the mass action, rise of critical velocities, and influence of a non-free axis of an engine on the occurrence of vibrations in a foundation; determination of the center of gravity, etc.

CONCERNING GRAPHICAL SOLUTION OF PROBLEMS OF TORSION (*Zur graphischen Lösung des Torsionsproblems*, A. Lechner. *Zeits. für das gesamte Turbinenwesen*, vol. 10, no. 29, p. 452, October 20, 1913. 3 pp., 2 figs. *mtA*). Brief, but interesting mathematical treatment of the graphical solution of problems on torsion. After recapitulating the fundamental equations of the theory of elasticity relating to torsion, the theory of St. Venant and the Thomson analogy, the author derives expressions analogous to those used in hydromechanics, of "form" and "form difference," and shows how, successively, the stress lines in the case of torsion may be constructed, as is done in certain hydromechanical problems. In technical problems it is often of importance to know the distribution of shear stresses in a cross-section. This may be shown at once by means of stress lines and their trajectories: where the lines crowd, the stress is large, and the entire system of curves follows the law of "constant specific form difference." This process may be used also quantitatively.

Refrigeration

DATA ON POWER CONSUMPTION AND OUTPUT OF AIR LIQUEFACTION AND OXYGEN MANUFACTURE PLANTS (*Angaben über Kraftverbrauch und Leistung von Luftverflüssigungs- und Sauerstoff-Anlagen*. R. Mewes. *Zeits. für Sauerstoff- und Stickstoff-Industrie*, vol. 5, no. 19, p. 317, October 4, 1913. 1½ pp. *cA*). Data on power consumption of air liquefaction plants. The author objects to some of the data on power consumption cited in G. Claude's recent book on *Liquid Air*. He gives tabulated data which show that at present the output of liquid air per h.p-hr. varies approximately from 0.05 to 0.14 liters, the higher values being due to the use of improved counter-current apparatus. The new Mewes air liquefaction apparatus uses, e.g., in its counter-current appartus eight serpentines (Tripler coils).

Steam Engineering

THE NEW SUPERHEATED STEAM COMPOUND LOCOMOBILE BUILT BY R. WOLF ON THE ADRIA EXHIBITION IN VIENNA (*Die neue Heissdampf-Verbund-Lokomobile Bauart R. Wolf auf der Adria-Ausstellung in Wien*, V. Müller. *Elektrotechnik und Maschinenbau*, vol. 31, no. 41, p. 870, October 12, 1913. 2½ pp., 6 figs. *d*). This locomobile has a peculiar arrangement of cylinders necessitated by the desire to obtain as high a steam economy as possible. As shown in Fig. 3A, the slide valve chests are placed close

to the cylinders, while the high and low-pressure cylinders are placed close to each other. The valve governing the exhaust of steam from the high-pressure cylinder and the inlet to the low-pressure cylinder provides the shortest possible path for the steam from the high to the low-pressure side, while in the low-pressure cylinder the exhaust openings are along the piston motion and are covered and uncovered by the steam piston. The piston valve on the high-pressure side takes care therefore only of the phases of pre-admission and cut-off for the high-pressure cylinder. The arrangement of the valve chests and cylinders as well as the direction of the flow of steam through them is schematically indicated in Fig. 3B. Balanced piston valves with elastic packing rings of the special type developed by the R. Wolf concern have been used.

Two New Fittings for Steam Boiler Plants (*Zwei neue Armaturen für Dampfkesselanlagen. Der praktische Maschinen-Konstrukteur*, vol. 46, no. 21, p. 58 (*Dampferzeuger*), October 1913, 1 p., 6 figs. *d*). Description

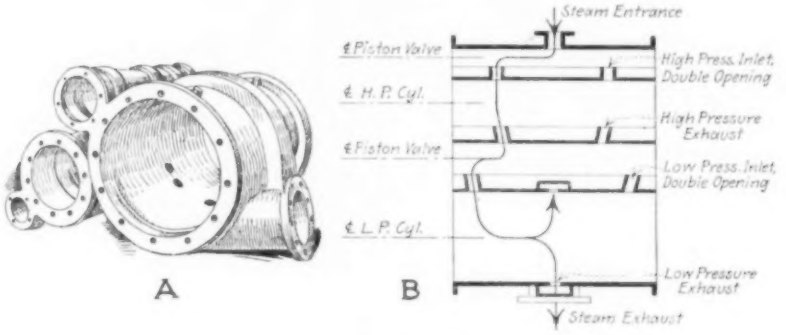

Fig. 3 R. Wolf Superheated Steam Locomobile

of the Ferranti steam valve and pressure regulating valve for simultaneous use with live and exhaust steam. It is to be used in cases where exhaust steam has to be helped out by the admission of live steam, the latter being admitted independently, and the volume and pressure of both kinds regulated in accordance with the conditions of operation of the plant. The regulating device must therefore permit, when necessary, of letting the exhaust steam into the atmosphere. All this required a rather complicated combination of devices, which the new apparatus claims to combine in a single apparatus. It consists (Fig. 4) of two combined elements, *b* for exhaust steam, and *l* for live steam; *b* is a piston valve moving in a slotted guide. In the valve *b* there is another valve *c* which is held, by means of a spindle and butterfly wing, in the casing *D* in such a manner that the lower edge of its cone closes the distributing slot in the guide cylinder along the upper edge of its cone. The piston valve *b* stands further in connection with the spindle *g*, the latter being acted upon by the lever *k* and live steam valve *f*. The interdependence of the parts *c*, *b* and *f* is what insures the automatic operation of the device.

THE DEVELOPMENT OF THE OERLIKON STEAM TURBINE (*Die Entwicklung der Oerlikon-Dampfturbine*, J. Karrer. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 43, p. 1698. 7 pp., 26 figs. *dh*). Semi-historical description of the Oerlikon steam turbine gradually developed from the Rateau impulse turbine. Prof. A. Stodola tested a 628-kw Oerlikon mixed pressure turbine, and found the efficiency of the low-pressure part to be 80 per cent (not considering bearing friction and radiation losses); the efficiency of the entire aggregate was found to be 75.4 per cent. In the high-pressure part four wheels ran in the pressure of the incoming ex-

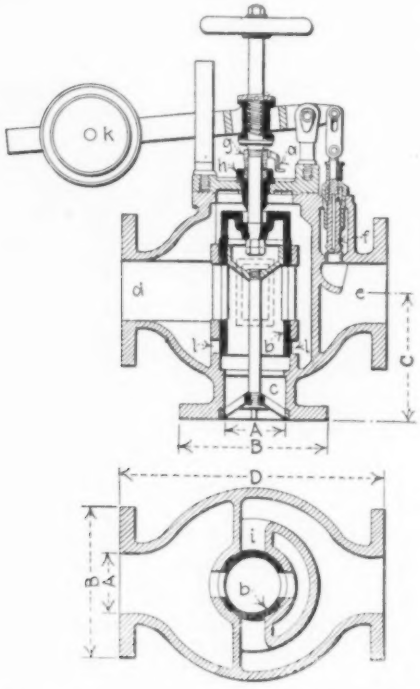

FIG. 4 FERRANTI PRESSURE REGULATING VALVE

haust steam at no-load, which constituted a loss of 19 kw, or 3 per cent of the total load.

STRESSES IN THE BLADING OF SHIP TURBINES DUE TO DYNAMIC EFFECTS AND THEIR RELATION TO RUPTURES OF BLADES (*Die Beanspruchung der Beschaufelung von Schiffsturbinen durch dynamische Wirkungen und ihre Beziehung zum Schaufelsalat*, Schumacher. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 42, p. 1668, October 18, 1913. 4 pp., 3 figs. *mt*). Dynamic stresses arising when the speed of a steam turbine is changed may under certain conditions prove dangerous for the blades of the turbine, either when, owing to excessive bending oscillations, the blades of the runner run into those of the guide, or when, owing to repeated stresses,

the material of the blades deteriorates and finally breaks; the latter usually happens so that the runner blade cracks near its root, and the free end sticks out and strikes the guide blades. The danger of such occurrences is the least in the case of turbines which allow a considerable axial play, and employ only comparatively short blades; it is minimized by having the elastic limit of the blade material as high as possible, and its specific weight as low as possible, and decreases in inverse proportion to the square of the blade thickness.

NOVELTIES IN LOCOMOTIVE CONSTRUCTION ON THE PRUSSIAN-HESSIAN

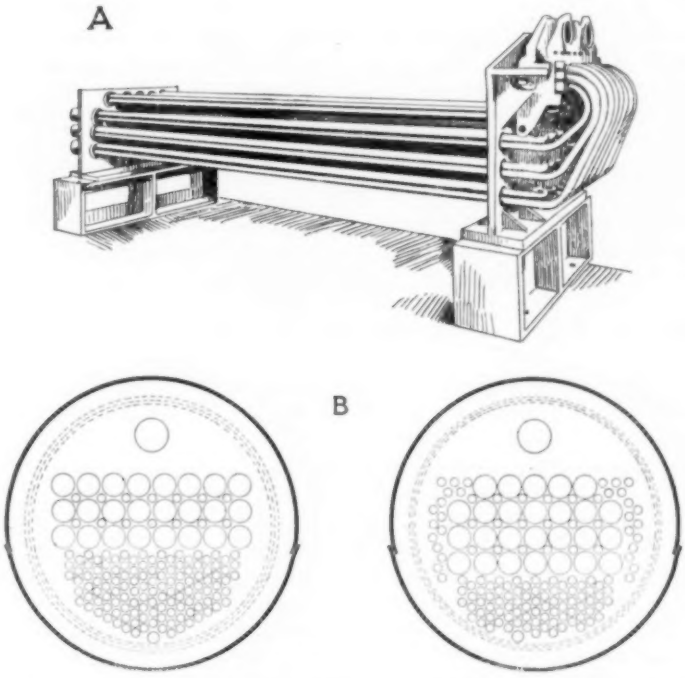

FIG. 5 NEW GERMAN SUPERHEATED STEAM FOUR CYLINDER LOCOMOTIVE

STATE RAILROADS (*Neuerungen an Locomotiven der preussisch-hessischen Staatseisenbahnen*, G. Hammer. *Glasers Annalen für Gewerbe and Bauwesen*, vol. 73, no. 872/8, p. 136, October 15, 1913. Serial article, not finished. *d*). Description of the 2C type fast-train superheated steam four-cylinder locomotive. When the first locomotives of this type were built, there were numerous cases of bridge ruptures in the upper corner of the copper tube plate of superheated locomotives, all the ruptures having apparently the same look. Previously undesirable phenomena of throttling have been also observed in the superheater, and therefore in the new type a different superheater and fire tube arrangement have been provided, viz., instead of the usual three horizontal batteries of superheater elements,

eight in a row, four horizontal rows are now used, the upper row of five, and the other three of seven tubes each. There are therefore 26 tubes instead of 24, with but a slight decrease of the surface of evaporation, due to the fact that to the right and left, instead of the eliminated smoke tubes, ordinary flue tubes are installed. A greater freedom for the expansion of the firebox is thus provided, and a longer life of the tube walls expected. Fig. 5A shows the new arrangement of the superheater, and Fig. 5B the old (left) and new (right) arrangement of the flue and smoke tubes of the locomotive.

Strength and Testing of Materials

DATA OF TESTS OF AN EXPLODED STEAM AUTOCLAVE (*Prüfungsergebnisse eines explodierten Dampffasses*, G. Goldberg. *Zeits. für Dampfkessel und Maschinenbetried*, vol. 34, no. 43, p. 523. 1½ pp. *e*). The material of a steam autoclave which exploded while in operation was tested at the Royal Testing Laboratory of Gross-Lichterfelde West. It served for melting an organic compound under a pressure of 15 to 18 atmospheres, by the heat supplied from outside by a lead-zinc bath at a temperature of 250 to 450 deg. cent. (482 to 842 deg. fahr.). The material was wrought-iron sheets supposed to be protected on the inside by a cast-iron jacket (it was found that actually only the barrel, and not the cover was protected by such a jacket). The investigation after the explosion showed that the cast iron fitted quite loosely on the wrought-iron sheets, and easily fell off when the piece was sawed through. Both the barrel and the cover burst in the explosion.

Test pieces taken from parts of the boiler in the neighborhood of the ruptured section, were tested partly at the outside air temperature, and partly heated up to 900 deg. cent. (1652 deg. fahr.). Tension and bending tests showed that the material fully answered to the usual requirements, and still the fact remained that it burst explosively. Another series of tests was therefore undertaken. Four fine-line crosses were made on a strip of metal cut from the cover, 35 mm (1.4 in.) wide, two crosses on each side of the strip, and the distance between them carefully measured by a comparator. The parts between the cross marks were then cut out by a planer, and the distances measured a second time. It was now found that while the distance on one side slightly decreased, that on the other side increased, which shows that one side was under compression, and the other side under tension. Neither the metallographic, nor the chemical investigation gave any indications of serious deviations from the normal conditions in metal of that class, and it appeared as if the cause of the explosion would remain a mystery. This mystery was partly solved by means of the notch shock test, which shows once more the importance of this method of testing boiler plates. The material, when tested at room temperature, had a very low coefficient of bending (practically zero), usually broke at the first blow, and appeared to be decidedly brittle. When the test pieces were heated for half an hour at 500 deg. cent. (932 deg. fahr.) and tested after being cooled in the air, the results were much better, and still better for pieces heated up to 900 deg. cent. (1652 deg. fahr.). It appears therefore that the brittleness of the material at the time of

the explosion was due neither to original defects, nor to overheating of the material, since overheated material would have to be annealed at 900 deg. cent. (1652 deg. fahr.) to show a material improvement, while here an improvement was observed already at 500 deg. cent. (932 deg. fahr.). The brittleness was not due to the presence of the cast-iron jacket either, since parts not jacketed were as bad as those covered by cast iron. Further tests were made with test pieces heated in a Heraeus electric furnace to 200, 300, and 400 deg. cent. (392, 572, and 752 deg. fahr.), as rapidly as possible taken out from the furnace, and tested under shock. The highest values were obtained for pieces heated to 200 deg. cent., while the values corresponding to higher temperatures proved to be lower, though superior to those obtained at room temperature. It appears therefore that

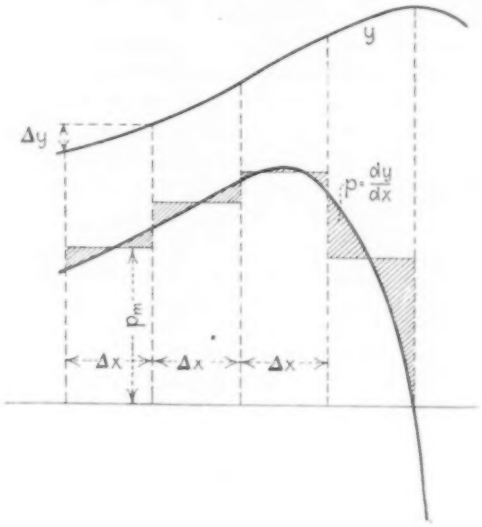

FIG. 6 GRAPHICAL DIFFERENTIATION

while nothing absolutely certain as to the cause of the explosion could be established, it was probably due to the fact that the boiler was stressed mainly at temperatures between 200 and 300 deg. cent. (392 and 572 deg. fahr.); at this temperature internal strains were produced which, after the material was cooled, led to the appearance of brittleness, these changes in the structure of the material being of such a nature as to be intensified by repeated action of the causes which originally produced them.

The main interest of this investigation lies in the fact that the usual tension and bending tests, metallographic and chemical investigations did not contribute much towards the explanation of the explosion, and that it was mainly the notch shock test that did it.

Miscellanea

A SIMPLE AND EXACT METHOD OF GRAPHICAL DIFFERENTIATION (*Ein einfaches und genaues Verfahren der graphischen Differentiation*, H. Holzer.

Zeits. für das gesamte Turbinenwesen, vol. 10, no. 29, p. 455, October 20, 1913. 1 p., 1 fig. *p*). The proposed method is based on the fact that differentiation may be considered as inverted integration. To find an integral of some curve $p = f'(x)$ (cp. Fig. 6), one has only to plot the areas $p_m \Delta x$ of the curve p to some scale as ordinate difference Δy of the integral curve y. Inversely, the ordinate differences Δy of the integral curve y will give the dimensions of the corresponding areas $p_m \Delta x$ of the differential curve p, and thereby, since the basis Δx in both curves is the same, the magnitude of p_m. This permits of determining the average heights of p_m of the succeeding areas of the curve elements, and all that remains is to plot the differential curve in such a manner that it shall give sections of equal area, the average height p_m being used. If the sections Δx be selected equal, the difference of ordinates Δy of the given curve may be used for the average height p_m of the section areas of the differential curve. It is, however, of advantage to multiply Δy by some integer in order not to obtain differential curves that are not too flat.

Garbage Incinerator Plant at Trieste (*I forni d'incinerimento delle immondizie á Trieste*, G. P. *L'Industria*, vol. 27, no. 42, p. 674, October 19, 1913. 2 pp., 2 figs. *d*). Description of the Trieste garbage incinerator plant. It is of the Herbertz type, with the Herbertz device for treating slags by dropping them into cold water and thus disintegrating. The plant has two batteries of furnaces, each of three chambers, and each with a daily capacity of handling 90 tons of garbage. The heat developed from the battery (only one battery at a time is used now, the other being for reserve purposes and future developments only) is used to drive two Tosi 300-h.p. steam engines, in their turn driving electric dynamos. The slags, broken up and sorted, are sold.

ACCESSIONS TO THE LIBRARY

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This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

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A new profusely illustrated handbook of machine design and mechanical engineering, in which the various chapters are prepared by engineering specialists and experts, with a view of forming not only a textbook for students of this branch of engineering, but also a handy reference book for the practising engineer. The work has been very favorably received and reviewed by the German technical press.

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MEETINGS

MILWAUKEE MEETING, OCTOBER 8

The first meeting of the Milwaukee section was held October 8, when Prof. A. G. Christie, Mem. Am. Soc. M. E., of the University of Wisconsin, gave a talk on The Uses of Pitot Tubes for Measuring Air. The talk was based on the paper by Mr. Rowse published in The Journal of the Society for September. The meeting was well attended. Old and new members of the Society are joining the local section and there never was a time when greater interest was shown in the work of the Society.

ST. LOUIS MEETING, OCTOBER 15

A meeting of the Associated Engineering Societies of St. Louis, under the auspices of The American Society of Mechanical Engineers, was held on October 15. Mr. L. A. Day, mechanical engineer of the St. Louis Water Department, read the paper of the evening, The New Turbine Pumps at the Chain-of-Rocks. An interesting discussion followed, in which Prof. E. H. Ohle, John Hunter, E. H. Tenney, G. M. Peek, and Messrs. Greensfelder, Wall and Russell participated.

BOSTON MEETING, NOVEMBER 19

The November meeting was a joint meeting conducted by the Boston Society of Civil Engineers, the American Institute of Electrical Engineers and The American Society of Mechanical Engineers coöperating. The paper, entitled Engineering Lessons from the Ohio Floods, was presented by John W. Alvord of Chicago, who was retained last spring to study the effects of the floods in Ohio the early part of this year and to suggest methods for protecting the districts affected. Mr. Alvord referred first to the geographical features of the country affected, particularly up-river from Dayton and Columbus, and called attention to the extent to which building in the large cities has spread over the river plains and limited the main river bed. He pointed out the fact that the physical characteristics of the region about these cities indicated that at some time in the past, conditions had prevailed similar to those which had produced the recent floods and that the disposal of the flood water had required all the outlet afforded by the conformation of the sites. He showed how the occupation of the low lands by buildings, the restriction of the river channeds and the building of railway embankments and bridges particularly had served to dam back the flood waters and very much increase the damage done.

Attention was called to the exceedingly high velocities developed through openings in these embankments and the resulting scour; also the effect which floating buildings and other debris have in stopping up the open-

ings through bridges, especially those of heavy masonry type, and instanced cases where the difference in level between the up-stream and down-stream side of such obstructions amounted to several feet. Lantern slides were shown illustrating these various points as well as the general destruction; of these a series showing the great erosion at certain points in the river bed where huge fields of rock were fairly quarried out and distributed over large areas, was particularly striking.

The speaker described projects for the control of these rivers which included a series of emergency storage reservoirs up-river from both Dayton and Columbus. In this connection he pointed out the difference between a system with capacity for handling the whole of such an exceptional rain fall such as was practicable above Dayton and a system of only partial capacity like that suggested above Columbus; called attention to the precautions which were necessary in the latter case to prevent the spill from these reservoirs coming together at the junction of the rivers below in such a manner as to form a crest which might closely approach or equal that due to an unrestricted flood.

CINCINNATI MEETING, NOVEMBER 20

The November meeting of the Society, a joint meeting with the Engineers' Club of Cincinnati, was one of unusual interest and attracted an attendance of 120. The address of the evening was presented by Elwood Haynes of Kokomo, Ind., on the new alloy, Stellite, which has attracted so much attention for its characteristic of great hardness. The speaker referred to experiments made by him about thirteen years ago in the reduction of semi-rare metals through their compounds, and discussed the physical characteristics of chromium, cobalt, and tungsten, and the remarkable alloys formed by chromium and cobalt, and by chromium, cobalt, and tungsten. He stated that over one hundred alloys of different combinations of these three metals, together with a fourth, molybdenum, had been made by him, all of which were characterized by extreme hardness and resistance to oxidization or other chemical action; and that the name Stellite had been given to this series of alloys.

The samples shown by the speaker possessed a high lustre and extreme hardness. Some of the tools easily scratched glass and pared light shavings off of steel wire nails, apparently with no damage to the cutting edges. A hammer, a draw knife, a table knife, and several chisels were exhibited, besides several very interesting specimens of metallic cobalt, molybdenum, and tungsten. The speaker reviewed the circumstances that had prompted him to try Stellite in a boring mill, after a failure to secure the full capacity of the machine from the use of high speed steel. Up to that time he had made only small tools and tableware out of it, believing that its property of remaining untarnished would make it desirable for these purposes. The success of the Stellite tool in the boring mill led to its use in lathes for making spiral gears, resulting in a great saving. In the two instances cited, the capacity of the machines had been more than doubled. This led to its introduction to the trade as a material for metal-cutting tools.

The specimens of Stellite and tools of Stellite shown by the speaker

resembled silver and had a beautiful polish. The speaker stated that it had been used in contact with corrosive acids and was entirely unaffected by them. It, of course, contains no iron; a small amount of iron injures it and much iron ruins it. It is distinctly magnetic, though less so than iron. It is extremely hard and must be cast into shape and ground, as it cannot be machined. Some softer kinds of the alloy can be forged with some difficulty when hot; but the harder alloys retain their extreme hardness when hot, which is the reason for the admirable service the material gives as a metal-cutting tool. In many cases the capacity of machines could be doubled by its use. It is about five times as expensive as the best high speed steel. The subject was extensively discussed and great interest was shown in the specimens.

CHICAGO MEETING, NOVEMBER 19

The first meeting of the season, held at the Sherman House, was a pleasing affair, being preceded by a dinner with a hundred and sixty-two in attendance. W. F. M. Goss, President of the Society, and Ambrose Swasey, Past-President, were in attendance. The evening was devoted to an informal talk on the Iron and Steel Industry of Chicago by Wm. A. Field, general superintendent of the Illinois Steel Company at South Chicago. Mr. Field told in an interesting manner of his early experiences in the steel industry, and brought out the fact that the remarkable development of this industry has been the result of painstaking efforts to enlarge the output ratio of the plants by continuous operation, and by increases of efficiency of both men and machines, with steadily increasing wages to the former.

Past-President Robt. W. Hunt followed with an interesting account of the organization of the old North Chicago Rolling Mills, which later developed into the present South Chicago Works of the Illinois Steel Company. E. M. Hagar, President of the Universal Portland Cement Company, referred to the growth of the cement industry, which had formerly been but a weakling child of the steel plant, and has now outgrown its parent. H. J. K. Freyn called attention to the close connection between the development of the gas engine and the steel industry.

NEW HAVEN MEETING, NOVEMBER 21

The first quarterly meeting of the season in New Haven was held on Friday, November 21, in the Mason Laboratory of Sheffield Scientific School, the attendance exceeding 250, the seating capacity of the lecture room.

The afternoon session, over which E. S. Cooley, chairman of the New Haven Committee on Meetings, presided, was opened at 3 o'clock, Coöperative Industrial Research being the topic assigned. Papers were presented on Coöperative Industrial Research at the Sheffield Scientific School with Connecticut Manufacturers, by Dr. L. P. Breckenridge, professor of mechanical engineering, Sheffield Scientific School; Research Work of the Bureau of Mines, by Prof. O. P. Hood, chief mechanical engineer of the United States Bureau of Mines; Coöperatinon of State and University for Industrial Research, by Prof. A. N. Talbot, of the Engineering Experiment Station of the University of Illinois, read by Wm.

Kent Shepard; and Oxy-Acetylene Welding Applied to Boiler Seams, by Henry Cave, of the Autogenous Welding Equipment Company, Springfield, Mass., followed by a demonstration of welding and cutting by the oxy-acetylene torch.

During the intermission a test was made of an automobile, measuring the horsepower and gasolene consumption at different speeds, and a demonstration was given of the use of compressed air tools by Mr. Lawson of the Chicago Pneumatic Tool Company, using a new Sullivan two-stage compressor.

About 75 engineers sat down to dinner at 6 o'clock in the Yale Dining Club and enjoyed a social hour.

Mr. Cooley again presided at the evening session, which opened in the laboratory at 7.30 p.m. Calvin W. Rice, Secretary of the Society, made a few brief remarks on the work of the Society and the features of interest in the coming annual meeting; and papers were presented on Safety Devices used in Connection with Grinding Wheels, by R. G. Williams of the Norton Company, Worcester, Mass.; Accident Prevention in Europe and the United States, by Dr. A. D. Risteen of the Travelers Insurance Company, Hartford, Conn.; History of the Manufacture of Brass, by W. B. Edwards, of Ansonia, Conn., read by H. L. Seward; Experiments with Residence Heating Boilers at the Mason Laboratory, by D. B. Prentice, of the mechanical engineering department of Sheffield Scientific School; and Motor Car Testing, by Prof. E. H. Lockwood, of the Sheffield Scientific School. The interesting exhibits and the enthusiasm of the large number present augurs well for the New Haven meetings and repays the committee for their efforts.

A more complete account of the papers and discussions will be published in another issue of The Journal.

NEW YORK MEETING, NOVEMBER 11

The paper of the evening was by C. V. Kerr, Mem. Am. Soc. M. E., on A New Centrifugal Pump with Helicoidal Impeller. It dealt with a style of pump intended to be driven by small steam turbines in connection with the auxiliaries of power plants, or for irrigation or drainage service where large volumes of water at low lift are to be handled. The paper was profusely illustrated by lantern slides. Dr. W. F. M. Goss, President of the Society, attended the meeting and made a few remarks at the close of the paper. He said that he liked to think of the centrifugal pump or the steam turbine as a simple thing, a device responding to very simple ideals, which came into existence from the very fact that it was simple and could be easily made. In the development of these conceptions, however, we have been led up to complicated processes and it is marvelous to think what has been done in the development of the centrifugal pump —how by applying mathematics (which really is good sense systematized), by applying our knowledge of assured facts and by the employment of a proper system of analysis we can design a pump to do almost any sort of work. The paper was then discussed by Carl George DeLaval, Harry Sinclair Hillman, Frederick Ray, Selby Haar, William A. Shoudy, and John H. Lawrence.

PHILADELPHIA MEETING, NOVEMBER 19

A joint meeting of the Society and Franklin Institute was held on November 19 with an attendance of a hundred and thirty. The paper of the evening was presented by Dr. R. H. Fernald, Consulting Engineer of the U. S. Bureau of Mines, and Professor of Dynamical Engineering of the University of Pennsylvania, entitled "Producer Gas from Low Grade Fuel." He referred to investigations that have been made by the U. S. Bureau of Mines on the utilization in gas producers of fuels heretofore not regarded as adapted to the economic production of power and discussed the results of same. The many interesting developments that have resulted therefrom were considered in their relation to the elimination of the smoke nuisance, the centralization of power and its development and distribution. The paper was illustrated by lantern slides, and numerous specimens of the low grade fuels investigated were shown. The paper was extensively discussed.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The second regular meeting of the Armour Student Branch was held November 5 and the speakers of the evening were: H. D. Gumpper, whose subject was Fans and Blowers; and L. Bunge, who discussed Safety Devices for Elevators. Both authors were members of the Student Branch. The papers were extremely interesting and well illustrated by lantern slides. Mr. Gumpper dwelt upon the Sirocco fan, showing its superiority over other types, and backing his arguments by tests. Mr. Bunge confined his remarks to safety devices for electric and hydraulic elevators.

CARNEGIE INSTITUTE OF TECHNOLOGY

At a meeting of the Carnegie Mechanical Engineering Society held on November 11, a paper on Helical Reduction Gears was read by C. E. Bates, of the class of 1909. The author dealt entirely with the three processes of Citroen, Wuest and Faucus, and gave in detail the construction of the machines used for cutting the gears by the different processes, and the advantages to be derived from each. In conclusion Mr. Bates compared the merits of helical and spur gears, illustrating his points with data recently obtained from experiments which he performed on reduction gears in the mechanical laboratory of the school. Professors Trinks, Mem.Am.Soc.M.E., and Sprowl entered into the discussion.

COLUMBIA UNIVERSITY

The Mechanical Engineering Society of Columbia University held its first meeting of the year on November 7. The speaker of the evening was R. S. Barnaby, whose subject was Model Aeroplanes. Various types were described and the value of experimenting with models under conditions similar to those met with in actual practice was discussed. The author explained also the greater relative stability of the model over the man-carrying machine, giving illustrations from experiments made by himself. He said that he had met with the best results with models with the elevating plane in front of the main plane, and thought that there was chance for the greatest development along these lines.

CORNELL UNIVERSITY

On November 19 Prof. D. S. Kimball talked on The Relation of the Fine Arts to the Useful Arts. He pointed out the interdependence of the two up to a certain point and from there on, their divergence. He said that every new machine went through a period of subjugation to over decoration, e.g., the modern cash register. Many lantern slides illustrative of the main points were shown.

The Sibley College Student Branch held a meeting on October 22, at which Prof. R. C. Carpenter, Mem.Am.Soc.M.E., spoke of the value of membership in the branch, the duty of the Society to the branches, and the duty of the branches to the Society. Professor McDermott told of his two years' engineering work in Brazil, and Prof. Albert W. Smith, Mem.Am.Soc.M.E., related several anecdotes of early life at Cornell; he also gave an account of the dinner recently given Professor Sweet on the occasion of his 81st birthday.

LEHIGH UNIVERSITY

At the meeting held on November 11 of the Lehigh University Mechanical Engineering Society, E. P. Humphrey spoke on Coal Breakers. After taking up the description of the methods of cleansing coal, Mr. Humphrey entered into a detailed description of the construction of a coal breaker, which he followed by a description of the operation of the breaker. The second speaker of the evening was H. A. Hoffman, flow meter specialist of the General Electric Company, who gave an illustrated lecture on the Flow Meter. The author opened with a brief history of the instrument and then discussed the different types of meters, giving the advantages and disadvantages of each.

LELAND STANFORD JUNIOR UNIVERSITY

On October 28 the Mechanical Engineering Society of Leland Stanford Junior University combined with the Electrical Society to hold a smoker for all members of the two departments of the university, the object of which was to acquaint the underclassmen with the two societies that they might take an interest in them. George M. Brill, Past Manager and Past Vice-President of the Society, was present and spoke a few words to the students.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

A meeting of the Mechanical Engineering Society of Massachusetts Institute of Technology was held on November 12, at which C. B. Rowley spoke on Cold Storage Insulation. His paper covered the following points: cork in its growing state, the discovery of the insulation properties of cork, its first use for cold storage insulation, the various forms of cork and the particular application of each, and the construction necessary that each might be employed to its best advantage.

PENNSYLVANIA STATE COLLEGE

At a meeting of the Pennsylvania State College Student Branch held October 17, the speaker of the evening was W. R. Little, whose subject was Fuels for Internal-Combustion Engines.

The second meeting of the year was held on October 22, when excellent

talks were given on the subject of Gasolene as Fuel for Automobiles. Mr. Little, of the class of 1914, presented the opening paper and led the discussion. Professors Moyer and Deimer, Members of the Society, and Messrs. Hall, Foell and Slack too part in the discussion.

POLYTECHNIC INSTITUTE OF BROOKLYN

A meeting of the Polytechnic Institute of Brooklyn Student Branch was held November 1, when G. Harding lectured on The Economic Significance of Fire Waste. He began with the amount of fire waste in the United States for every year, and showed how fire insurance companies endeavored to make good this yearly loss, but how they failed in years of extraordinary disaster. He then pointed out the fact that fire departments only served to stop fire, not to prevent loss, and concluded with a discussion of various methods by which fire waste could be prevented.

PURDUE UNIVERSITY

The opening meeting of the year of Purdue University was held on September 13. Members of the faculty and of the senior class outlined the plans of the Society for the coming year.

At the meeting held on October 14, L. W. Wallace, professor of locomotive and car design, described the tests that had so far been made on the machine erected by the Master Car Builders' Association at Purdue for the determination of the blow dealt on the rail by a loaded car with flat wheels. He also outlined the scope of further tests that are to be run.

The speaker at the third meeting of the year, which was held on October 28, was Professor Peffer of the School of Chemical Engineering. His subject was the Relation of Chemistry to the Mechanical Engineer.

W. E. Starks, of the class of 1914, spoke before the society on the evening of November 11 on Halftone Engraving or Photography. He described the processes in use for the production of halftone pictures and zinc etchings and went into both the photographic and the chemical sides of the subject.

RENSSELAER POLYTECHNIC INSTITUTE

At a meeting held on October 9 at the Rensselaer Polytechnic Institute Student Branch, A. M. Greene, Mem.Am.Soc.M.E., gave an interesting account of his trip abroad with the Society last summer. F. L. Eidman, Stevens Institute 1909, gave a brief account of the founding of the student branch there, and told of the work it had accomplished.

The meeting held October 23 was addressed by C. E. Davies, of the class of 1914, who spoke on the power development of the New York Mills Company, at New York Mills, N. Y. The talk was followed by a discussion upon the details of steam power plant design.

The branch was addressed by W. Kelly at the meeting held on November 6. He gave a very complete account of the life of the late Dr. Diesel. This was followed by a description of the Process of Separation of Magnetite Iron from Its Ores, by H. W. Henry.

STATE UNIVERSITY OF IOWA

The Prevention of Industrial Accidents was the title of an illustrated lecture given by F. H. Guldner before the State University of Iowa on

October 14. The talk was limited to those phases concerning the mechanical engineer; the importance of accident prevention and the methods adopted by large firms in reducing accidents, being especially emphasized.

On November 11, the mechanical and electrical engineering student members, together with the Compass Club, held a joint meeting. Talks were given on the Senior Inspection Trip through Chicago; Gary, Ind.; and Milwaukee, Wis.; the subject being treated from the mechanical, electrical and civil engineers' viewpoint. G. Konvalinka, student member of the Society, represented the mechanical engineers.

STATE UNIVERSITY OF KENTUCKY

A meeting of the State University of Kentucky Student Branch was held on November 3 and Prof. F. Paul Anderson, Mem.Am.Soc.M.E., gave a talk on What is The American Society of Mechanical Engineers. The speaker outlined the future purposes of the Society and what it stood for in the engineering world. In the course of his remarks, he brought to the attention of the members the necessity of a code of ethics for the engineering profession. A. R. Bennett, a student member, followed with a digest of the paper on The Art of Enameling or the Coating of Steel and Iron with Glass, by Raymond F. Nailler, and published in The Journal for October. Methods of treatment and some of the chemistry of the processes were brought out.

UNIVERSITY OF CALIFORNIA

At a meeting held on October 21 of the University of California Student Branch, L. P. Denny read a paper on Scientific Management; and G. H. Briggs, one on Green Economizers, with particular reference to their installation and operation.

At the meeting held November 4 the following papers were given: The Measurement of Steam Flow, by R. Hanson; and Installation and Operation of a Funicular Railway, by L. T. Kennedy. Mr. Kennedy devoted most of his discussion to the difficulties attendant upon the construction, and also the operating devices used.

On November 18 A. C. Moorehead discussed the Gas Engine Carbureter. P. H. Landon gave a talk on the Effect of Moisture in the Intake of a Gas Engine, which was followed by a discussion on the part of the members of the society upon the particular point raised by the paper, namely, whether or not the efficiency of the engine might be increased by the use of moisture with the fuel mixture.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch was addressed on November 11 by H. M. Wood, Mem.Am.Soc.M.E., on Special Machine Operations in the Manufacture of Lathe Parts. The methods of production of the various parts of the lathe made by the Lodge & Shipley Machine Tool Company were explained in detail and illustrated by over fifty lantern slides. Special emphasis was placed on the merits of the longitudinal and diametrical stops of the lathes. A special, independent motor-driven feed lathe for boring lathe spindles and locomotive axles was also discussed in detail. The discussion which followed took the form of questions asked by the audience and answered by Mr. Wood.

UNIVERSITY OF ILLINOIS

Facilities for Handling Work was the title of the paper read by B. W. Benedict, director of Shop Laboratories, at a meeting held on November 7 before the University of Illinois Student Branch.

UNIVERSITY OF KANSAS

At a meeting of the University of Kansas Student Branch on October 30, the date of the Annual Meeting of the section was fixed as December 12, and plans were discussed for the coming meeting.

H. H. Feierebend read an excellent paper on Airships in France, England and Germany. The mechanical features of the various types were described in detail, which was followed by a discussion by those present. H. N. Baugher read a technical report on Ball Compound Engine and Accessories at the University of Kansas. L. C. Angevine gave an extract on the Eastman Kodak Company's plant from a paper published in the American Machinist. It was stated that the plant covered 150 acres, was of 20,000 h.p. capacity, and that as many as 500 miles of moving picture film was manufactured per day. Messrs. H. C. Ackerman, O. T. Potter, H. L. Newby and others discussed the paper.

At the meeting held on November 7 the senior trip to St. Louis and Keokuk was reported. Mr. Berwick gave an interesting report on Ice and Refrigeration, including a brief account of the bi-annual Icemen's Congress and their trip. Mr. Hagenbush reported on Machinery, and Mr. Beauchamp told of the Cedar Rapids hydroelectric development, the difficulties of construction, and some of the mechanical details. He said that the plant was designed for an ultimate capacity of 160,000 h.p., which would be used for the production of aluminum and carborundum products. This report was discussed by Prof. F. H. Sibley, and W. J. Malcolmson, and H. L. Newby. Mr. Cunnick gave some of the humorous experiences of a trouble-shooter from Gas Engine.

UNIVERSITY OF MAINE

The newly organized Student Branch at the University of Maine held a meeting on November 3 for the purpose of electing officers. The following were chosen: Chairman, E. E. Fowler; vice-chairman, W. L. Wark; secretary-treasurer, A. B. Hayes.

UNIVERSITY OF MISSOURI

On Octobr 20 a meeting was held of the University of Missouri Student Branch at which Professor Hibbard, Mem.Am.Soc.M.E., presented a paper on the New Experimental Laboratory, and the Experimental Lathe.

On November 4 Professor Wescot presented a very interesting paper on Concrete.

UNIVERSITY OF MINNESOTA

The first meeting of the newly organized Student Branch at the University of Minnesota was held on November 13 and the following officers were elected to serve until the annual election in January: Chairman, A. Buenger; vice-chairman, M. Ovestrud; secretary, J. A. Colvin; treasurer, J. L. Hartney. The branch already numbers fifteen members.

UNIVERSITY OF WISCONSIN

On October 16 a joint meeting of the student branches of the electrical, civil and mechanical engineers was held at the University of Wisconsin. Illustrated talks were given by Prof. L. S. Smith, of the department of civil engineering, Mr. Disque of the department of electrical engineering, and Professors Thorkelson and Christie of the department of mechanical engineering and members of the Society, on impressions received by them during recent European trips. Professor Smith discussed the matter of roads and pavements in Germany and England; also the plans adopted by European countries for city planning. He compared the methods used there with those of this country and also the results obtained. Both Professor Thorkelson and Mr. Disque gave talks of a more general character, while Professor Christie described various types of engines used in power work. These last three were members of the party of the Society visiting Germany last summer.

YALE UNIVERSITY

On October 24 the Student Branch of Yale University held its first meeting of the year. Twenty-three new members were enrolled and the following were elected to serve on the governing board: H. S. Houston, R. L. Dickey, D. B. Porter. An interesting address was given by Prof. J. W. Roe, Mem.Am.Soc.M.E., on the advantages of membership in the student branch and subsequently in the Society, and on what such membership means to men in the engineering profession.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

1016 Man to take charge of an Indianapolis office of firm of merchant engineers. Dravo-Doyle Company.

1104 Wanted, for woodworking concern: first-class estimator for sash and doors, exterior and interior house finish and trim, able to estimate, make details, write factory orders, and arrange contracts for all kinds of building work; must be a man of ability, integrity, and personality. Salary according to ability. Address Edward F. White, 51 Chestnut Ave., Rutland, Vermont.

1105 Thoroughly practical, hustling shop foreman, experienced in engine and pump work; a thorough mechanic, able to produce the maximum output of highest quality at lowest cost, and familiar with best and latest up-to-date practice. State age, experience, references, and compensation expected. Apply through the Society. Location, Massachusetts.

1106 Man to design a line of small gasolene and crude oil engines; must be more than a mere draftsman experienced in the actual design of engines, preferably of the internal-combustion type; salary not exactly determinate, but probably would not reach $2500 at the start. Apply through Society.

1107 A young man wanted to manage the manufacturing and installation of a new household article that has been thoroughly tried out and perfected. One who is able to furnish a few thousand dollars for half interest.

1108 A moderate sized plant located in the neighborhood of Franklin, Va., manufacturing high-grade steam specialties, desires a factory foreman or superintendent. Must be able to prepare working drawings, a manager of men, a good executive, thorough and energetic, with experience in the use of standard jigs. No foundry experience required. In replying, state salary expected, experience in full, age and references. Apply through the Society.

1109 An engineer, thoroughly experienced in the design and operation of oil engines. Should be familiar with foreign development and practice. State age, experience, compensation. Apply through the Society.

1110 Factory foreman or superintendent, practical machinist, good judge of men, excellent opportunity for an energetic experienced man who can handle 100 men and produce rapidly accurate heavy machine work. Eastern location. Apply through the Society.

1111 Salesman for middle west and to represent direct factory making heavy machinery. Salary $2000 to $2500. Apply through the Society.

1113 Salesman for New York City to represent factory making heavy machinery. Salary $2000 to $2500. Apply through the Society.

1114 Experienced mechanical engineer who in addition to having a thorough technical education and practical knowledge of boilers and engines, has demonstrated executive capacity, initiative, and ability to do business with other men without friction; must be under 35 years of age and preferably hold a responsible position at the present time.

1118 Good engine draftsman for concern manufacturing engines and boilers. New York State.

1119 Plant consisting of machine, boiler, pipe, blacksmith, foundry and pattern shops and employing about 250 men, wants first class superintendent, an American, between thirty and thirty-five years old, good training and experience and thoroughly up to date in shop methods. Previous experience as superintendent of a large plant not essential, provided applicant has proper qualifications for the position and experienced in the handling of men in the works. Western location. Confidential; apply through the Society.

MEN AVAILABLE

330 Member, technical graduate, 31 years of age, desires to secure position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation; extensive training and experience in central power station work, designing and purchasing equipment, superintending construction and operating departments; consulting engineering work on large properties, including the investigation of power production and cost reduction for large corporations in connection with the consolidation of isolated plants; experienced in mill and reinforced concrete construction work; at present employed and desires a change for advancement.

331 Sales engineer, experience in handling high-grade specialties in power transmission and machinery lines; known to machinery and supply trade of United States and Canada for past eight years.

332 Mechanical engineer, age 30, graduate Massachusetts Institute of Technology, with four years' experience in large central station, would like superintendency of medium sized light and power station or the generating department in a larger central station; thoroughly familiar with all modern methods of economy in power plant; also sale of electricity.

333 Member, mechanical and electrical engineer, technical graduate, experienced in design, construction and installation of electrical and hydraulic apparatus, desires position with consulting engineer or engineering construction concern. At present employed as works manager of eastern concern making hydraulic apparatus.

334 Junior member, age 31. Eleven years' practical experience in the development, installation and operation of large steam turbine and electrical apparatus. Five years as chief engineer for one of the largest interurban railways in western Pennsylvania. At present employed as assistant electrical engineer in large industrial proposition. Well informed, good address and appearance. Thorough operating and commercial training. Desires position as chief engineer of power stations with interurban railway or light and power company in middle states or middle west. Salary $2000-$3000.

335 Member desires position as works manager, superintendent or engineer; competent to organize all departments of manufacturing plant along modern lines; long experience, best references; expert on developing new inventions.

336 Junior member, age 30, experienced in design, construction and superintendence of high and low-tension substations, transmission lines, etc., desires connection with large contracting firm or manufacturing plant requiring services of graduate mechanical and electrical engineer. Best references, moderate salary.

337 Member, technical graduate, age 40. Locomotive shop, steel works and general construction experience. Inspection of rails, structural material and galvanized product, desires position as inspection engineer.

338 Member, graduate mechanical engineer, ten years' experience in designing and manufacturing gas, gasoline and oil engines and all modification; special study of tractors for agricultural purposes; can design and build a tractor that will make a profit for the manufacturer and purchaser. At present employed. Location, middle west preferred. Salary $3000.

339 Mechanical and electrical engineer, member, 35 years of age, technical graduate, with about 15 years' experience in mechanical and electrical work, as power plant, design, construction, and operation, electrical equipment of manufacturing plants, heavy mechanical machine design and construction, sub-station and street railway work, and reports on hydroelectric development.

340 Member; now employed, with wide experience in design and construction of machinery and buildings, manufacturing, systematizing and accounting, desires permanent position in New York City; salary to start $4000. Graduate Massachusetts Institute of Technology in mechanical engineering, post graduate course in electrical engineering.

341 Stevens Institute of Technology graduate, mechanical engineer, wishes position as assistant to plant or efficiency engineer or works manager. At present employed, desires a change and an opportunity to make good, and responsibility will be the reward for conscientious work. Future considered before salary.

342 General utility executive, technically educated as a mechanical engineer, who, under the titles of assistant vice-president and secretary, has served as a general utility man for well-known manufacturers of machinery; duties including sales, advertising, development of new ideas,

pushing out work and general office management; seeks a responsible position where a wide engineering knowledge will be of value.

343 Mechanical engineer, technical graduate, 31, desires executive position. Ten years' experience in the determination and control of manufacturing operation costs, power plant and general plant engineering; well fitted for production engineer or assistant superintendent of large plant where results will be appreciated.

344 Junior member, at present employed as mechanical engineer and estimator with large boiler company, desires responsible position with growing concern offering better opportunities; ten years' experience as draftsman, designer, estimator, purchasing agent and assistant manager, familiar with all branches of boiler manufacture and general plate work.

345 Sales manager, exceptional experience in design and selling power plant and other machinery, as well as construction and installation, fitted by thoroughly practical and technical training to direct manufacture and sale of product. Specially good at getting results from branch offices and salesmen. Valuable acquaintance gained by 15 years' successful selling in territory east of and including Pittsburgh and Buffalo. Cornell graduate.

346 Member, 36 years of age, graduate mechanical engineer, 15 years' broad and general experience in designing, estimating and constructing various types of mill buildings, factories, railway shops and power stations; thoroughly familiar with all kinds of building construction. At present employed as superintendent on a contract job.

347 Recent Columbia University graduate wishes to connect with a large industrial concern or an industrial engineering firm where there is a future for a hard, energetic worker; willing to start in any position; location immaterial; best references. Address Mechanical Engineer, 74 West 92d Street, New York City.

348 Member, college graduate with degree of M.M.E., served as machinist before entering college, 15 years' experience in charge of shops and building and operating steam and water power plants; at present chief engineer of an electric railway system, but desires a change. Specially qualified as a designing engineer.

349 Member, age 42, desires position as assistant manager or general superintendent; practical mechanic, wide experience in office, stores and shop in the manufacture of internal-combustion engines, stationary and tractor, marine engines, pumps, mining machinery, steam and locomotive work, electrical apparatus. Design and erection shop and foundry buildings, steam, electric, pneumatic and hydraulic power plants. Competent to assume full charge.

NECROLOGY

JAMES RICHARD BELL

James R. Bell, who died at his home in Hazeldene, Ightham, Kent, England, on July 14, 1913, was born on August 21, 1841, in Wick, Scotland, in the house of his grandfather, James Brenner, a famous engineer. Mr. Bell was educated at the Aberdeen Gymnasium, and served his apprenticeship with the Gardiners in London. His early work was on various surveys in England and Wales and on the construction of the Cairo Ramelah Railway.

In 1868 he went to India, being connected first with the irrigation department in the Madras Presidency, and in April 1870, was transferred to the state railways directly controlled by the Government of India, where he remained until his retirement in 1896.

Mr. Bell's most important work in India was in connection with the building of railways and bridges, and he devised many novel means for the training and improvement of diluvial rivers, on which he was a recognized authority. Among his achievements are the Empress Bridge over the Sutlej River, the Aneroati Railway, the railway to Hyderabad, Deccan, the Jumna Bridge, near Mutra, an important bridge over the Sutlej at Ferozepore, and a bridge over the Chenab River at Sher Shah, near Multan. Mr. Bell also investigated the bridging of the Indus at Sukkur, where a steam train ferry had been provided for the Indus Valley State Railway, and over which Mr. F. E. Robertson subsequently constructed the cantilever structure now standing.

In 1891 Mr. Bell became consulting engineer to the Government of India for state railways, receiving a permanent appointment to this position in 1894, which he held until his retirement in 1896.

On his retirement Mr. Bell was still in excellent health and he practised as a consulting engineer. He is said to have been the original of Findlayson in Kipling's "Bridgebuilders," and

was regarded by his contemporaries in India as an engineer of extraordinary attainment, though his services were never more than formally acknowledged and never adequately honored by his government. Apart from the successful and very rapid construction of several fine railway bridges and the evolution of the only proper and scientific method of controlling the flow of itinerant rivers when bridged, he deserved the most substantial recognition of his work on the Ruk-Sibi Railway during the Afghan War, not only because through the exercise of marvellous organizing and directing capacity he performed almost a miracle in railway construction, but because he provided possibly the only means of ending a critical situation in Afghanistan.

WILLIAM GEORGE CHAMBERS

William George Chambers, chief engineer of the National Cash Register Company, Dayton, Ohio, died in New York on May 1, 1913.

Mr. Chambers was born at Belleville, Ontario, on April 2, 1874, and on completion of his education in the public schools, served his apprenticeship with the Bagley & Sewall Company, Watertown, N. Y. In 1900 he entered the employ of the National Cash Register Company as a model-maker in one of the inventions departments. The following year he won promotion and became foreman of one of the assembling departments. In 1905 he was sent to Canada as superintendent of the company's factory at Toronto, returning the following year as foreman of another assembling department. Two years later he was made supervisor of the entire assembling division and in 1910 became assistant general superintendent. When the important position of chief engineer of the company was created in 1912, Mr. Chambers was named to fill the place, becoming responsible for the ordering of all changes and improvements in registers, the quality of the material used, and all the inspection, tool designing and toolmaking of the firm.

RUDOLPH DIESEL

The recent death of Dr. Rudolph Diesel is a severe loss to the engineering profession at large, as well as to the many personal friends of the distinguished engineer. Dr. Diesel, who had been spending a week-end at Ghent with M. Carels of Carels Frères, sailed from Antwerp in company with M. Carels and M. Luckmann,

chief engineer of the firm, on the evening of September 29, with the intention of attending the annual meeting of the Consolidated Diesel Engine Manufacturers, Ltd., in London. Upon arrival in Harwich next morning, it was discovered that Dr. Diesel was missing, having apparently fallen overboard during the voyage. Some days later his body was recovered, thus confirming the fears of his family and friends.

Dr. Diesel's career has been one of interest from the first. In the early eighties of the last century, as a student in the Technical High School of Munich, while listening to a lecture on thermodynamics by the famous Professor Linde, he jotted down in his notebook these words: "See if it would not be possible to realize practically the isothermal." It was only a carelessly scribbled line, but in it was the germ of a great idea, which in the mind of a man peculiarly fitted to "see" was destined to develop a dozen years later, into what may be justly considered as one of the most important achievements of mechanical engineering of the last century, the Diesel engine.

Rudolph Diesel was born in 1858, the son of a German family residing in Paris. In 1870 changed political conditions forced his father to move to London and to send the boy to Augsburg, Germany, the very place where, twenty-three years later, the first Diesel engine was placed on the testing stand, to be greeted at first with incredulity and then with the unstinted applause of the engineering world. The boy's youth was spent, in the methodical German fashion, in years of high school training and thorough drilling in engineering fundamentals under the competent supervision of men like Schroeter and Linde, interrupted from time to time by long visits to London where his father was still making his home and where he acquired that mastery of the English language which was such a pleasure to his many friends in this country.

From the beginning Diesel was kept in close touch with the problems of thermodynamics, first as assistant to Linde in his work at the Munich Technical High School, and later as his technical representative in connection with the manufacture of the Linde refrigerating machinery, then at its beginning. These studies resulted in Diesel's taking out a patent for a new engine in the early nineties, and in his publishing a book under the title, "The Theory and Construction of a Rational Heat Engine." The rational engine was based on a principle so simple that very few consented to believe in its truth, viz., that pure air could be compressed to so high a point

that the fuel injected into it would ignite and burn. Happily for Diesel, however, there were a few men like his former teacher Professor Schroeter, of Munich, and Professor Hartmann, of Charlottenburg, who expressed their belief that the engine would work on the new cycle, and their opinion was powerful enough to induce the largest two machine construction companies in Germany, the Krupp works and the Augsburg-Nuremberg Company, to unite in an effort to test out the invention.

Two years of trial followed. The first engine blew up as soon as fuel was injected, nearly killing Diesel himself. Alterations were made, an air supply pump for the injection of fuel added, but the engine would not run and was always a source of danger. "I myself," said Diesel in his talk before the Society in 1912, "would never have had the patience and the courage to continue the work after the disappointments of the first two years of experimenting, had I not been supported by an unalterable belief in the correctness of my mathematical deductions."

Finally, after four years of laborious experimenting, the correctness of mathematical deductions,—the true beacon of all engineering work,—was vindicated in the form of an engine working on an entirely new principle, with a thermodynamic economy practically not yet exceeded. From 1897 the name Diesel became attached to a new prime mover which has since been built in thousands of units.

The vindication of the principle of the Diesel engine led to a strenuous effort to promote its introduction into all fields where it could be used. The development of the horizontal engine, the marine Diesel engine, the high-speed engine for driving dynamos, and finally the Diesel engine locomotive with direct drive and electric transmission are matters of history, and it is to be noted with profound regret that the inventor's returns were by no means commensurate with the services he rendered to humanity.

The members of the Society who visited Dr. Diesel at his delightful home in Munich during the past summer were enabled to renew the acquaintanceship formed during Dr. Diesel's tour of America in 1912, when he spoke before the Society of his own work. It is seldom that one has so endeared himself to the members generally as did Dr. Diesel, and his death is a personal loss to the membership of the Society.

ARTHUR J. FRITH

Arthur J. Frith was born at Philadelphia, Pa., February 23, 1852, and died at Chicago, Ill., November 10, 1913, of acute dilation of the heart. Mr. Frith was educated at Georgetown College, Georgetown, D. C., and at the Rensselaer Polytechnic Institute, where he was graduated in 1873 with the degree of civil engineer.

As a young man Mr. Frith worked in steel and rolling mills and was sent to England for special information in regard to steel manufacture. He taught at Lehigh University; was assistant chief engineer in connection with the Mississippi River Commission on Government work; designer for the Newark Machine Tool Works, the C. W. Hunt Company, and engineer on coal-handling plants with the Trenton Iron Company; assistant chief engineer and designer with the Diesel Motor Company of America in 1898; secretary of the Washington Company, contractors, New York; and consulting engineer, New York. Latterly he was associate professor of mechanical engineering at Armour Institute of Technology, specializing in thermodynamics, gas and oil engines, compressed air and refrigeration. He was the author of a number of technical papers, the owner of various patents, and had done special research work on boiler efficiency, gas engine efficiency, regenerator efficiency, etc.

He was an engineer in the best sense, a lover of truth, very careful in considering the different aspects of a problem, giving each due weight, and deciding each point after intensive study. He truly sank himself in his work, and presented his final conclusions with such modesty and amiability that a casual observer might easily have failed to realize the conscientious work and clear insight which prompted the conclusion. In the early work of the introduction of the Diesel motor into this country, these qualities of mind and the thoroughness of his equipment in mathematics and thermodynamics were of inestimable value; and were gratefully acknowledged by the late Dr. Diesel. His domestic life was for years a very happy one. His wife was a lady of many pleasant accomplishments, and a cheerful disposition, which enabled them to accept the ups and downs of an engineer's life with a noble equanimity. They had one child, a boy of rare promise, who combined the fine qualities of both parents. In his eleventh year he was run over by an automobile and instantly killed in

the presence of his father, whose side he had left but an instant before. This was no doubt the cause of our friend's early death, to which the physician gives a technical name. E. D. MEIER.

LUDWIG HERMAN

Ludwig Herman was born in Prague, December 2, 1842, and died in Cleveland, Ohio, on October 21, 1913. He received his education at the University of Prague and in the machine shops of Vienna. In 1865 he came to America, residing first in New York, where he was employed by the Brush Electric Light Company and the Yale & Towne Manufacturing Company, and later in Chicago, where he became an engineer for the Rust Bridge Company. He was for several years chief engineer of the Detroit Bridge & Iron Works Company, in Detroit, Mich., and later became a member of the firm of the Fox & Hower Bridge Company of Chicago, designing and building numerous bridges all over the country, among them that over the Mississippi River at Hannibal, Mo., one of the largest bridges of its time. In 1885 Mr. Herman became general manager and engineer of the Buckeye Machine Company of Cleveland, Ohio.

Mr. Herman designed the first 20,000 candle power arc lamp for the Paris Exposition, and lowered the first electric light mast in 1885 at Akron, Ohio. He planned and executed the structural iron work of the tower of the Fairmount Street reservoir and executed the structural iron work for the additional stories and roof of the old court house of Cleveland.

He was a member of the Cleveland Engineering Society.

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Note—Numbers in parentheses indicate number of years the member has yet to serve.

THE NEED FOR COÖPERATION BY THE ENTIRE MEMBERSHIP

The following amendments to the Constitution, to increase the standard of membership will, if favorably acted upon, go into effect at the 1914 Spring Meeting. In publishing these amendments the Committee on Increase of Membership emphasizes the fact that its activities are being directed to securing applications from none but qualified engineers suggested by members of the Society. Every effort is being made by the Committee to impress each member that it is his duty to advise the Secretary of the names and addresses of all desirable members of his acquaintance and also to make a personal effort to secure applications.

The field which remains undeveloped embraces the larger portion of the country. Over 77 per cent of the membership is confined to ten States. We are *the Society of the industries*, yet in many industrial centers we have no adequate representation and we should be at work holding meetings and extending the benefits of the Society to these centers.

AMENDMENTS OPEN FOR DISCUSSION AT ANNUAL MEETING, DECEMBER 3

C-9 A Member shall be an Engineer or Teacher of Applied Science of thirty-two years of age, or over, and shall have been in the active practice of his profession for at least ten years and in responsible charge of important work for five years, and shall be qualified to design as well as to direct engineering work. Fulfilling the duties of a Professor of Engineering who is in charge of a department in a college or school of accepted standing shall be taken as an equivalent to an equal number of years of active practice. Graduation from a school of engineering of recognized standing shall be considered as equivalent to two years of active practice.

C-11 An Associate-Member shall be a professional engineer not

less than twenty-seven years of age, who shall have been in the active practice of his profession for at least six years, and who shall have had responsible charge of work as principal or assistant for at least one year. Graduation from a school of engineering of recognized reputation shall be considered as equivalent to two years' active practice.

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